NOVEMBER 18, 1957 PRICE 50 CENTS

Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN
RESEARCH AND DEVELOPMENT

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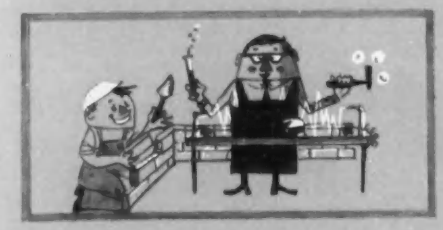
Research AND Development EDITION



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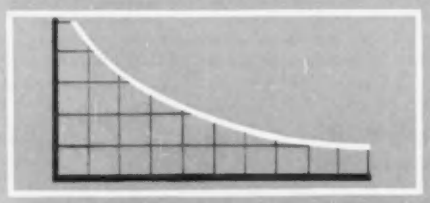

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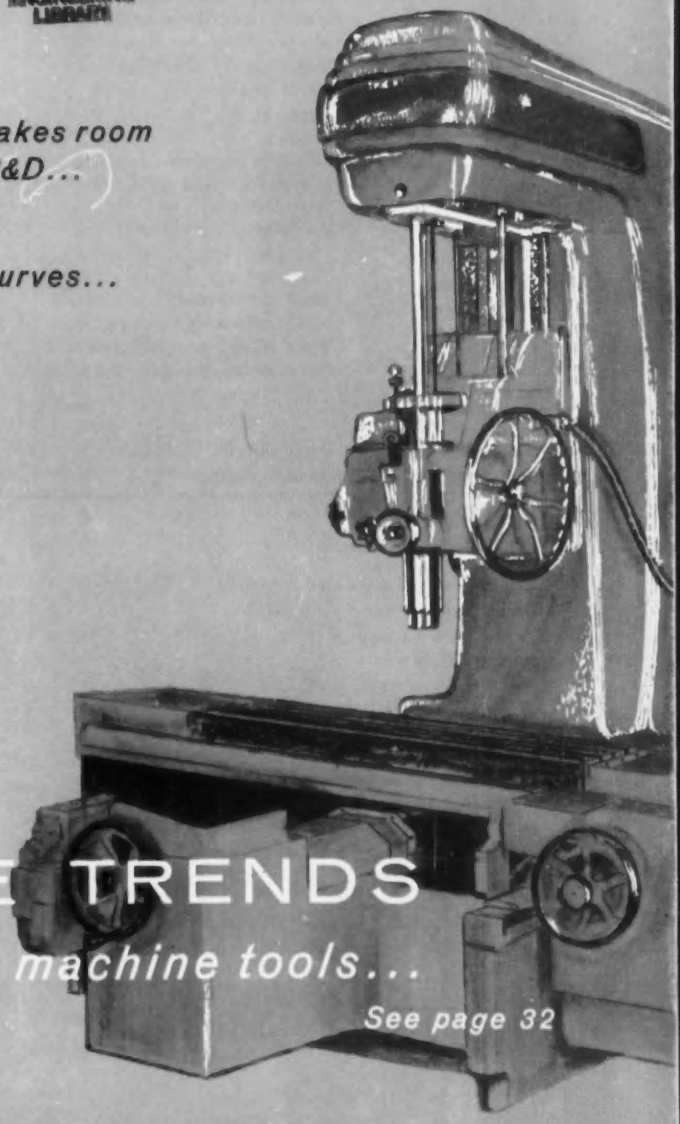

APPEARANCE TRENDS

in machine tools...
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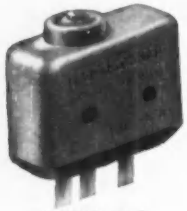
FOUR PROVEN ANSWERS TO SWITCHING PROBLEMS

Subminiature sealed switch is environment-free; mounts interchangeably with MS25085

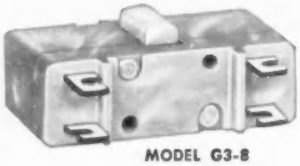


MODEL EF-3

Single Pole, Double Throw
Move. Differential, .004 Max.
Overtravel, .003 Min.
Oper. Force, 5 to 17 oz.
Release Force, 60 gram
Elec. Life Ratings:
150,000 ops. @ 125/250 V. A.C., 2.5 AMP.
100,000 ops. @ 125/250 V. A.C., 5.0 AMP.
50,000 ops. @ 30 V. D.C., (2.5 AMP., IND.; 4.0 AMP., RES.)
Amb. Temp., −65° to +180° F.

Sealed in a corrosion-resistant, treated aluminum enclosure, this tiny switch is environment-free; highly vibration and shock resistant. It carries 5 amps. at 125/250 V.A.C. with an electrical life rating of 100,000 operations. Low operating force and small movement differential make it ideal for bi-metal temperature, diaphragm operated and other "feather-touch" devices, while small size permits mounting singly or ganged in restricted space. Rugged and dependable, it has positive snap action.

Tiny 40 amp. basic switch has high capacity, longer life and constant stability of tolerances



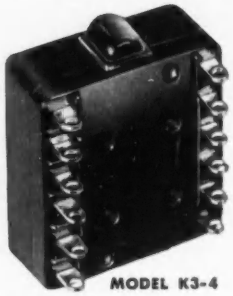
MODEL G3-8

Measuring only 1¾" x 43/64" x 35/64", the Electro-Snap G3-8 Basic Switch handles current ratings up to 40 amps. A new method of combining Electro-Snap's double-break action with a heavy-duty switching element assures electrical and mechanical life of 100,000 cycles at large capacities; also provides constant stability of tolerances and accurate repeatability. New plastic compound case gives the switch an ambient temperature rating of —100° to +300° F. with extreme shock resistance. Small size makes it ideal for motor controls and compact automation set-ups. A wide range of actuators is available.

OPERATING CHARACTERISTICS

Single Pole, Double Throw
40 AMPS @ 125/250 V. A.C.
@ 30 V. D.C. Res.
Oper. Force, 45 oz. Approx.
Overtravel, .015" Min.
Move. Differ., .055 ± .010

Simultaneous triple-pole switch interrupts 3-phase ac. circuits; 6-circuit control in a small package



MODEL K3-4

Triple-Pole, Double Throw
15 AMP., 125/250 V. A.C.
30 V., D.C. Res.
10 AMP., 30 V., D.C., Ind.
Overtravel, .015 Min.
Move. Diff., .028 ± .007
Mech. Life, 1,000,000 ops.
Elec. Life, 500,000 ops.

This Electro-Snap triple-pole switch simultaneously reverses current flow through three windings of a 3-phase motor up to 1 H.P. and interrupts other types of multi-switching installations. Instantaneous "make" and "break" snap-action of the three poles is independent of the speed of actuation—even extremely slow moving cams can be used.

The K3-4 Series offers designers a wide variety of 3-phase circuit hookups for servo-controls, to limit movement of machine members and as a start-and-stop switch which formerly were possible only with complicated relays or a number of separate switches. A large selection of standard actuators is available.

Small basic switch is low cost; directly interchangeable with AN3234 Specs

F2 SERIES

These Electro-Snap F2 Series snap action switches are extra-compact with extremely high electrical capacity for their size. Mechanical and electrical life at 1/32" overtravel is 150,000 operations, minimum, with accurate repeatability and constant stability of tolerances. Self-aligning springs provide contact wiping action rare in a switch of this size.

Durable case of special plastic gives the switch an ambient temperature rating of −100° to +275° F. or +375° F. Available, *at low cost*, in three basic models with a wide selection of actuators.

SERIES F2 BASIC SWITCH: F2-3: Single Pole, Double Throw
F2-2: Single Pole, Normally Open; F2-1: Single Pole, Normally Closed

OPERATING CHARACTERISTICS

Electrical Rating: 10 AMP. 125/250 V. A.C. 60 cycles
30 V. D.C. inductive and resistive (6 AMP, 30 V. D.C. for Airborne Application)
Operating Force, 7 to 12 oz.
Reset Force, 4 oz. Min.
Pretravel, 3/64 Max.
Movement Differential, .011 ± .005
Overtravel, 1/32 Min.

SEND COUPON FOR MORE DATA

ELECTRO-SNAP SWITCH & MFG. COMPANY
4246 W. Lake St., Chicago 24, Ill.

Please send data sheets on switch checked:

- ☐ EF-3 — subminiature sealed
- ☐ G3 — 40 Amp. basic
- ☐ K3 — Triple-pole
- ☐ F2 — Extra-small basic

NAME_____

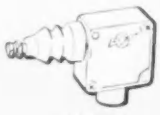
COMPANY_____

ADDRESS_____

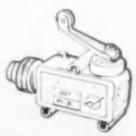
CITY_____ ZONE____ STATE_____

PRECISION SWITCHES

BASIC SWITCHES



DIECAST ENCLOSED SWITCHES



HERMETICALLY SEALED LIMIT SWITCHES

CONFORM TO MIL & AN SPECIFICATIONS

COMING NEXT WEEK . . .

the DESIGN edition

for November 25

ENGINEERS CAN BE FOUND— AND KEPT

by G. F. NORDENHOLT
Editor of Product Engineering 1933-1957

"The current shortage is the most constructive thing that has happened to engineers . . . it has compelled industry to pay salaries more nearly in line with their services, it has elevated the prestige of the engineer . . ."
These are the opening sentences of Mr. Nordenholt's report on visits with top executives and chief engineers in some 30 leading manufacturing companies. Read how industry selects—and keeps—top engineering talent for important positions in industry. Watch for the DESIGN edition—next week.

and
in addition . . .

the
DESIGN edition
for November 25

FEATURES

- **Lubricating with Air**
  A two-part report on current research at Franklin Institute plus practical design charts for hydrodynamic gas-lubricated journal bearings

- **Plastic Extrusions**
  Cut cost of plastic parts with inexpensive extrusion dies.

- **Instrument Gears**
  Seven rules boil down specifications to a practical minimum.

- **Less Noise from Small Engines**
  Acoustic principles applied to lower 2 and 4-cycle engine noise.

Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

R and D Research and Development EDITION

November 18, 1957 Vol. 28, No. 20

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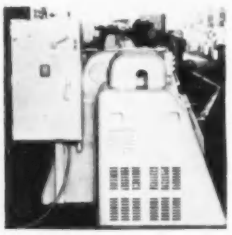
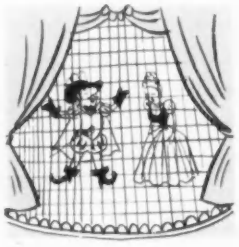


This week's Trends in Appearance Design (page 32) shows Detroit's influence on the world's most functional equipment—machine tools. Some of the "before" designs were ugly, it's true, but we'd drag our feet a bit when the more extreme efforts (like the pyramid-shaped lathe, left) are involved. How do you keep from tripping every time you walk past that lower corner?

Scientific research and development is not everywhere encouraged as it is in the US (see page 23) and new products don't always get the appreciation they deserve. We note the recent capture of a government tank by a wild tribe, the Hasti. When the Khan of the Hashti was asked about it later, he sheepishly admitted the theft, and added, "Just in time, too; we were running out of iron for horseshoes."



The three-act play appearing on page 39 caused considerable soul-searching in our offices these past few weeks. Has a technical magazine the right to print what is essentially fiction, even if the moral is pointed and important? Frankly, we don't know. And unless we experiment, readers have no basis for deciding. Please read the piece and let us know what you think.

Our Reader Service Department is headed by a charming young lady whose poise is never disturbed by the strange problems that cross her desk. Last week an assistant received a telephoned request for information on a Coffin & Hearse Co. At first glance PRODUCT ENGINEERING would hardly seem the right source for such information and, more than a little puzzled, the assistant passed the call to our heroine. It took about 15 seconds of thought then, "Oh, yes. Coffing Hoist Co. It's located in Danville, Illinois. . . . You're welcome."

ABP NOVEMBER 18, 1957 **Product Engineering** *A McGRAW-HILL PUBLICATION* Vol. 28, No. 20 ABC

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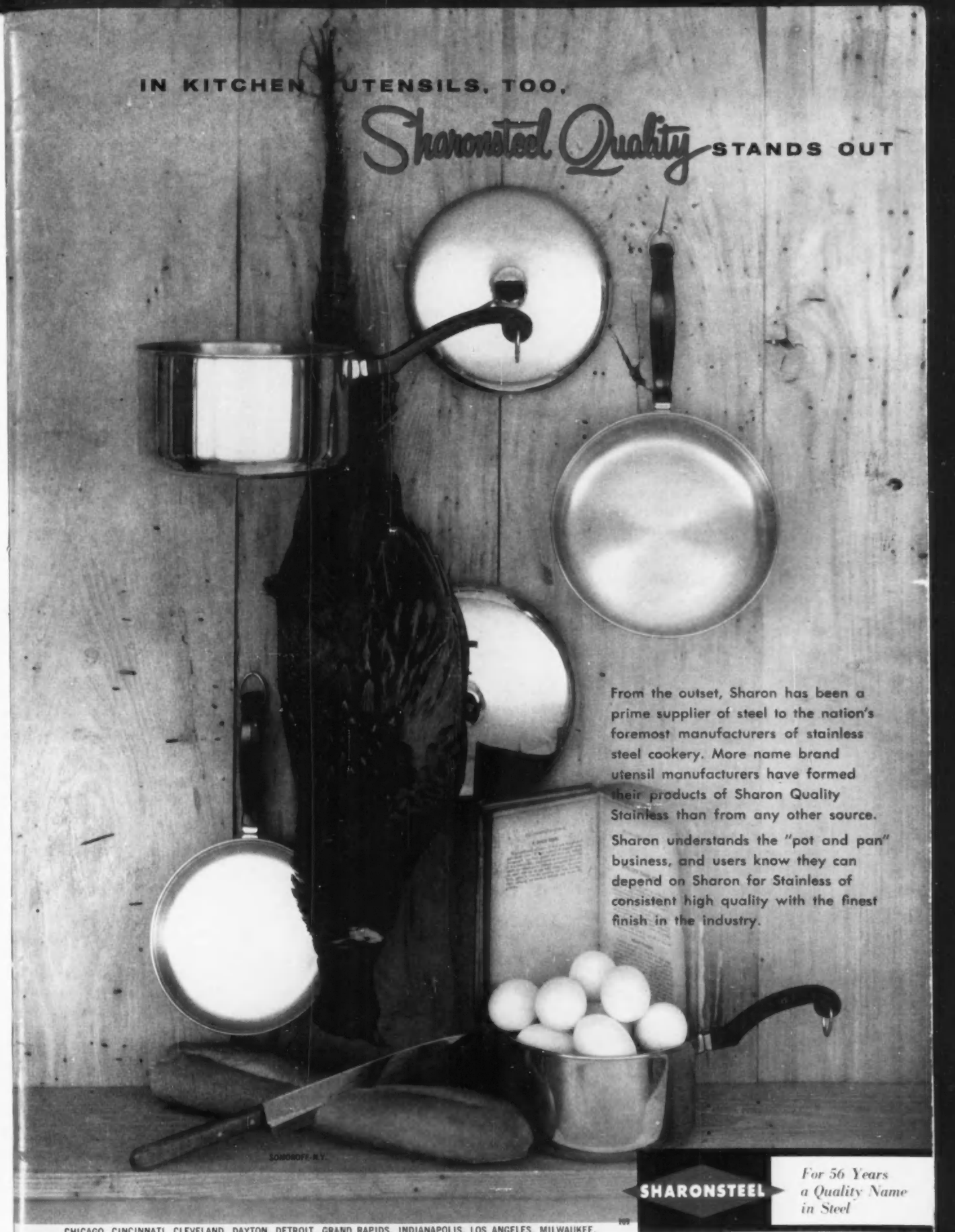
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SHARON STEEL CORPORATION, SHARON, PENNA.

READER TO EDITOR

Who Buys New Ideas?

To the Editor:

In your issue of October 7 you have an article by Dr. Warren A. Beck on choosing new products. In it he suggests that management may look for new ideas in ads placed by inventors in magazines devoted to new products. I am an inventor and would very much like to know what magazines Dr. Beck has in mind. I feel that the lack of such a publication or organization is one of the independent inventor's greatest problems.

Of course, an inventor who has access to a comprehensive list of manufacturers, such as Thomas' Register, can compile a list of the firms who are engaged in the line of work to which his invention relates. But when he goes to such firms, almost invariably he finds that their engineering staffs regard him as a meddlesome interloper who not only is endangering their jobs, but who is also insulting them by the mere implication that he, an outsider, has an idea of value to the company which they overlooked.

Yet, management always seems to assume that the report they will get from their engineers on an outside invention will be unbiased and objective! I have had several personal experiences of this nature, and never fail to be amazed at the childish innocence of management men in this respect. This is another matter of which Dr. Beck seems to be unaware—or perhaps he feels that nothing will be accomplished by discussing it.

—A. Auerbach
La Mesa, Calif.

Author Replies

To the Editor:

First of all I make a practice of scanning the ads appearing in *Wall Street Journal, Journal of Commerce, Magazine of Wall Street,* New York *Times,* etc. These publications frequently contain ads by manufacturers which describe the type of products they are seeking. I have personally inserted ads and was virtually deluged with replies from inventors. In addition, there are the numerous trade journals of a specific field such as *Product Engineering, Iron Age, Steel, Chemical Engineering,* etc. Manufacturers do advertise in these and an ad by an inventor listing a specific product would definitely attract attention.

There is a publication that is completely devoted to the difficult task of bringing inventor and producer together. It is *New Product Digest,* Perry-Brooke Bldg., Austin, Tex. In addition there have been two or three newsletters circulated among manufacturers in which inventors could list their items. Perhaps some other reader could contact *Product Engineering* with additional information on this score?

I am in full sympathy with Mr. Auerbach's keen insight into the difficulty of trying to interest company engineers in new products that they have not developed themselves. In fact, I have had considerable difficulty on that point myself. Naturally, space makes it impossible to discuss the problems of trying to overcome the narrowness of many technically trained men and the difficulty of obtaining a fair hearing from management once they have vetoed an excellent new product. Though nothing may be accomplished by discussing it, it remains a very real problem that is costing management throughout the country countless opportunities.

—Warren A. Beck, *Ph.D.*
Eastern New Mexico Univ.

The Right Decision

To the Editor:

Your publisher's letter in the Sept. 9 issue welcomes frank expressions on either editorial or advertising, and I would like to take advantage of this by commenting on the article, "Are Computers Oversold?" (Sept. 9, p. 40)

I make my living in the computer field. I not only agree with the general theme expressed, but have felt the same way privately for some time. A qualification must be stressed, however, which is that some applications are well worth the use of a computer, while others are not. In the first area, it is most often the technical calculation, while business applications fall in the second: i.e., "Let's put payroll on first, then look around and see what else we can do."

I must quibble with a statement made somewhat flippantly in your article about the companies that hire a "Director of Electronic Program." He recommends: "buy." If not, he would be recommending his own dismissal . . . or so states the author. It so happens that this is my exact position. I was hired to make this decision. My conclusions expressed informally to my management are: "don't buy." I haven't been dismissed. There's plenty of useful tabulating, systems and operations research work I can and am doing, and perhaps some day I will be in position to say that now's the time to buy.

Just wanted to set things straight.

—Name Withheld

Permanent Windshield Wipers

To the Editor:

In the R & D edition you pose the question, "Why don't they research and develop a windshield wiper that really works?" That thought has occurred to many; and since 1950 I've given a little time to investigation. The answer is simple.

Twenty-one million replacement wiper-blades are sold each year with deterioration designed into the rubber compound and into the mechanics of the blade itself. The automobiling public has, from experience, been educated to the necessity of renewing wiper-blades, like changing oil. Windshield wipers can be produced that will give efficient service without replacement for the average life of an automobile. My car is so equipped.

—Hugh Stewart
San Fernando, Calif.

More Elevator Shafts

To the Editor:

Germany isn't the only country to have individual elevator shafts. (Nov. 4, p. 60). I saw one in Athens, Greece, in 1949. It was made by a German company for the building in which Electric Bond and Share Co. of N. Y. had their offices. The up and down shafts are adjacent, and the one-passenger boxes ran at a continuous speed.

—Charles G. Kahant
Roller-Smith Corp.

News about HYPALON®

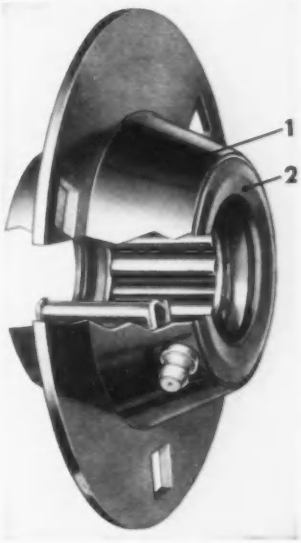
Convertible top coated with HYPALON resists sunlight, weathering, discoloration, cracking

When one large automotive manufacturer wanted a convertible top for new models that would give longer wear, HYPALON was specified as the coating over the canvas body. This newest DuPont synthetic rubber was chosen because it will not crack or harden under prolonged exposure to weather, and is exceptionally resistant to the effects of sunlight. HYPALON can also be compounded in a wide range of stable colors . . . important as a styling consideration in the competitive automotive industry.

HYPALON offers almost unlimited industrial design possibilities. It is particularly adapted to applications where exceptional ozone resistance and resistance to oxidizing chemicals are important. HYPALON also shows unusual resistance to hardening at elevated temperatures (250°-350° F.). For full information on the useful properties of HYPALON for design, just mail coupon below.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

Bearing gives smoother performance, longer life because of neoprene housing and shaft seal



1. Neoprene housing permits shaft alignment changes.

2. Neoprene seal retains lubricant, seals out dirt.

Flexible neoprene housing on roller bearing adapts to instant changes in shaft alignment

This new cartridge type roller bearing, introduced by the Rollway Bearing Company of Syracuse, N.Y., is designed for farm and industrial materials handling equipment. It is made in shaft sizes from 1/2 to 1 7/16 inches. The bearing's flexible neoprene housing adjusts to shaft alignment changes caused by vehicle movement, or shifts in load distribution on pulleys attached to the shaft. It permits misalignment between shaft and bolting flange of at least one degree. This adds considerably to bearing life and cuts fatigue on walls or panels to which the flange is mounted.

Rollway specified neoprene for the housing and shaft seal because it *keeps* its flexibility despite hard wear and extremes of temperature and humidity. Neoprene was also chosen for its outstanding resistance to oil and grease and the abrasion of dirt and grit. Regular bearing lubrication has no effect on the neoprene seal.

It's this *balanced combination* of properties that makes neoprene so useful for applications where severe service conditions would ruin ordinary rubber or less resilient materials. Neoprene resists acids, oil and grease, abrasion, sunlight and weathering. Mail coupon below for details on how neoprene's many useful properties have been designed into many industrial products, and how they can work for you.

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Better Things for Better Living
. . . through Chemistry

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☐ Please add my name to the mailing list for your free publication, the ELASTOMERS NOTEBOOK.

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Elastomer Chemicals Dept. PE-11
Wilmington 98, Delaware

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Firm _____
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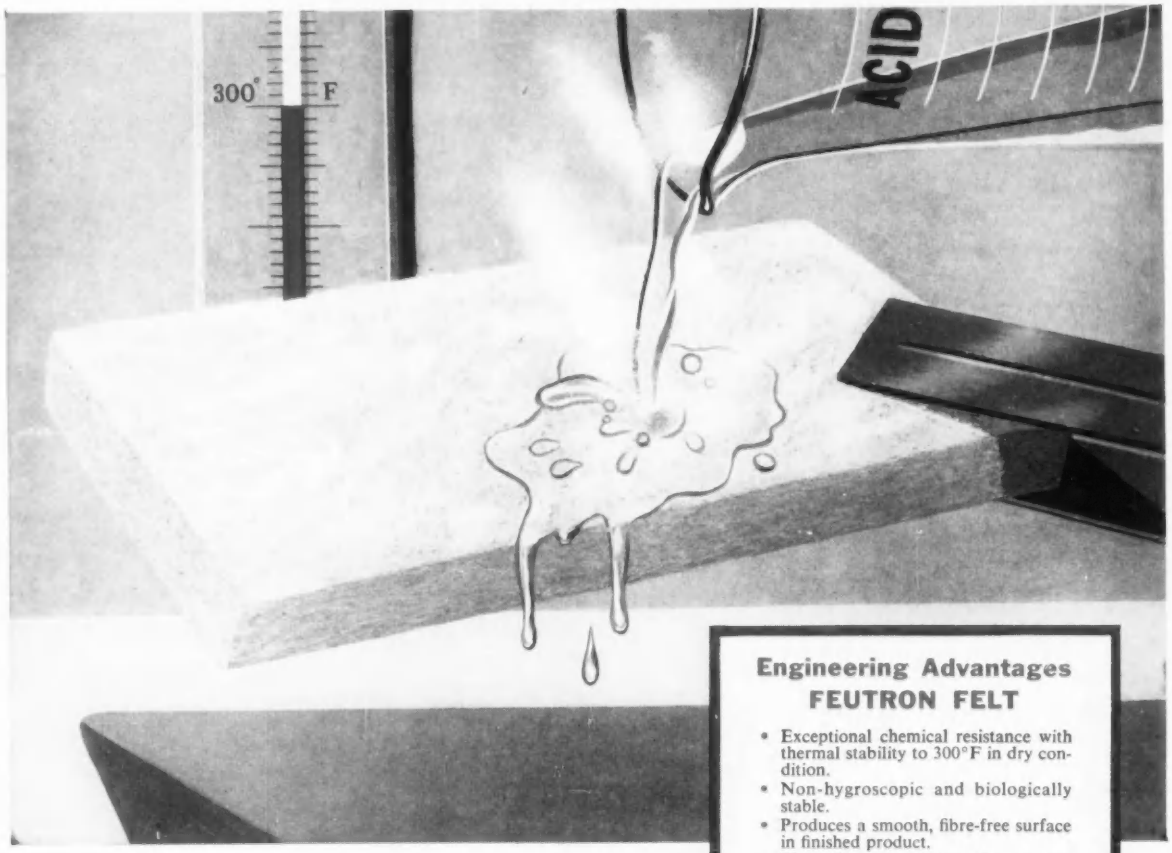
Feutron Felts

Withstand High Temperatures...Corrosive Conditions!



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DEVELOPMENTS TO WATCH...

Products can get sunburned . . .

. . . just as people do. And the results may be even more devastating. The same ultraviolet radiation that turns people beet-red causes breakdown of many plastics, coatings, and textiles. But real progress is now being made in preventing product "sunburn."

First, it's been found out that "blondes" among plastics—the light-colored materials like nylon and polyethylene in their natural form—are usually much more subject to ultraviolet than the darker ones like the phenolics (melamines and the acrylic plastics and fibers are exceptions to this rule). So one solution to the sunburn problem has been to give materials an artificial suntan, by incorporating dark pigments. The trouble is, the pigment not only changes color but affects other properties as well.

To get around this, such companies as American Cyanamid, Dow (a new entry in the field), and the Antara Chemicals Div. of General Aniline Film, are developing stabilizing and light-absorbing additives (generally salicylate and resorcinol derivatives) that do not darken the materials on which they are used. The compounds will protect many plastics, wood, textiles, and coatings, particularly when teamed with anti-oxidents and hydrochloric acid scavengers.

Until recently, there were no additives of this type which could be successfully applied to either nylon or polyethylene. Now, though, one company thinks it has an answer to the nylon problem; and says it is getting good results on polyethylene by combining ultraviolet absorbers and anti-oxidents.

Computers on the farm? . . .

. . . Why not, say H. J. Behm and R. G. Fuller of Battelle Memorial Institute. The need to feed a growing population, using fewer workers, less land, and more machines, puts a premium on efficient farm management, and "will require control or optimizing of many variables in the production process." Data-taking units might work well in reporting such information as amount of sunshine, and moisture, air temperature, and soil condition. These factors could be fed to a computer, along with such variables as type and amount of fertilizer applied, so that it would be possible to predict the ripening date and estimate the volume of the harvest.

Computers could aid livestock production, too, by helping determine relationship between rate of growth, rate and type of feed consumption, and climatic factors.

It's not such a wild idea. At least one poultry breeder now records pertinent information on each bird as he moves along the nests, and later transfers the information to punched cards which are processed to obtain production and marketing data.

Sampling devices are worth investigating . . .

. . . if you're looking for new products. Taking test pieces and batches from moving films and conveyor belts is a problem that cuts across many industries. So far, most companies have built their own; yet a commercial device could have a sizable market. The photo shows one such device, developed by Eastman Kodak for snipping paper samples. Another, described at a recent American Mining Congress meeting by A. H. Blyth of Marcona Mining Co., Peru, is an ingenious track-mounted car, equipped with scoops, for taking ore samples as they move along a conveyor belt. Here, problems to be solved included compensation for sidewise movement and allowance for sag of the belt.

Sampling device, with razor-sharp jaws, snips paper samples on the run at Eastman Kodak, eliminates tearing of web, operates at high speed so samples can be sealed in container before they lose moisture. Safety aid is long handle which keeps operator's hands out of harm's way.

(continued)

DEVELOPMENTS TO WATCH...

Compression ratios of 12:1 are on the way . . .

. . . say Chrysler and Standard Oil of California engineers. They're predicting it "within the next 5 or 10 years. But, with the Edsel already at 10.5 to 1, it may be even sooner than that.

Compression ratios of 12:1 will, of course, call for fuels well over 100 octane—costly fuels, but they'll offer advantages too: Rated hp of a 325-hp engine will rise to 365, rear-wheel hp (max) will go from 165 to 186, and acceleration time for 0 to 60 mph will drop from about 9.6 to 8.8 sec. (For information on other new trends in engine design, see Nov. 11, p. 98).

Engineers at California Research, Standard's research subsidiary, are of course devoting much attention to new automotive fuels and engines. But that's by no means their only effort. They're working hard on radiation-resistant fluids (for atom-propelled planes and other applications), radioactive testing and measuring devices (using gold 198, nickel 63, antimony 124, and krypton 85) and a new synthetic fiber (see p. 17).

Current research on radiation-resistant fluids centers on 5-component materials based on alkyl aromatics rather than the silicon tetrachloride-alcohol combinations which have received the lion's share of attention so far.

Sticking the stick-proof . . .

. . . is a problem that sounds like a paradox, but it's mighty important for potential users of solvent-resistant plastics, fibers, and other materials. Assembly and repair can become major headaches if there's no way to bond one material to another.

The fluorine plastics, epoxies, and polyester and nylon fibers have all been hard to handle in this respect. Recently, though, pressure-sensitive adhesives have been developed for Teflon. There is a new bonding agent for joining Dacron and nylon to synthetic rubber; and a series of adhesives is being developed to permit production of synthetic fiber laminates. Borden Company is working on these, and has three compounds ready for marketing. Borden's says they are "specifically designed to obtain high-strength, flexible bonds of plastisol and organosol film to nylon and many other synthetic fabrics." Using the new bonding agents in a two-coat system, adhesion values exceeding 20-lb peel strength have been recorded on fabric strips 2 in. wide. Samples may be obtained from the company's Chemical Div., Peabody, Mass.

Photosensitive plates . . .

. . . for printing make it possible to go from picture to press in 15 minutes, and could pave the way for new techniques in dial and instruction plate production. The process, still in the laboratory stage at DuPont, is surprisingly simple: The plate, a special photosensitive polymer, is exposed to ultra violet light for about 2 min through a high-contrast negative. This hardens the exposed areas so that they will remain when a water-wash removes the unexposed material. That's all there is to it. The plates are less than $\frac{1}{8}$ in. thick, may be used on rotary or flat-bed press. They're not ready for commercial application, though. Says DuPont, "commercial availability of this plate is a good two years away."

This, incidentally, is only one of several new applications of plastics to printing. Also under test, at least two printing plants, are nylon printing plates, produced by more conventional methods.

Image thrown on plastic becomes a plate for the printer. Speedy DuPont process uses photo-sensitive resin.

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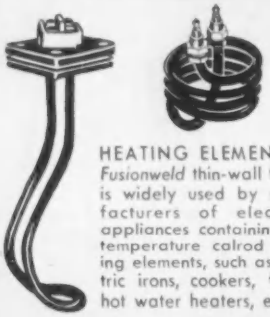
TUBING AIDS by Fusionweld

Spark Solutions to Production Problems



HEATING ELEMENTS—*Fusionweld* thin-wall tubing is widely used by manufacturers of electrical appliances containing low temperature calrod heating elements, such as electric irons, cookers, fryers, hot water heaters, etc.

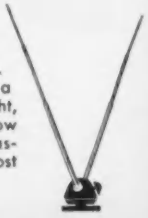
OIL LEVEL INDICATOR TUBES—Avon's low cost, high production fabrication and forming of steel tubing with new spot welding technique in attaching brackets, clips or fittings to *Fusionweld* thin-wall tubing has been widely adopted by most motor car manufacturers.

TUBULAR PUSH RODS—A current automotive development replacing solid steel push rods with *Fusionweld* steel tubing. These have swaged ends or hardened steel inserts (spot welded) in tubing ends. A high degree of concentricity is maintained with maximum run-out held to .020.

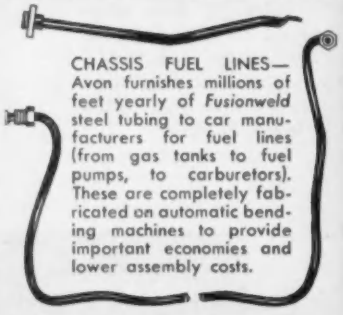
GAS SPACE and WATER HEATER TUBES—Several new developments by *Fusionweld* have cut costs by eliminating expensive brass fittings and non-ferrous tubing or pipe from thermostats to burners, replacing with low cost inverted flare nuts and one piece steel fittings brazed or spot welded to Avon steel tubing.

ENGINE OIL FILTER TUBES—For both internal and external use with brazed fittings attached. *Fusionweld* tubing can be beaded, swaged and sheared to meet specifications of motor car, truck and tractor manufacturers.

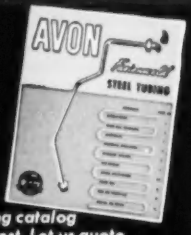
MISCELLANEOUS APPLICATIONS—*Fusionweld* thin-wall tubing is extensively used by toy manufacturers, umbrella and TV antenna makers, also for electric light fixtures, tubular furniture, etc. *Fusionweld* offers a tough, light weight, extremely ductile, low cost steel tubing easily formed for most requirements.



OIL SPACE and WATER HEATER TUBES—*Fussionweld* thin-wall tubing provide manufacturers of this and similar equipment with smart economies by replacing non-ferrous tubing and fittings with special steel fittings combined with *Fusionweld* steel tubing.



CHASSIS FUEL LINES—Avon furnishes millions of feet yearly of *Fusionweld* steel tubing to car manufacturers for fuel lines (from gas tanks to fuel pumps, to carburetors). These are completely fabricated on automatic bending machines to provide important economies and lower assembly costs.



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DEVELOPMENTS TO WATCH...

$38-billion defense spending ceiling will be exceeded . . . .

. . . if the spending in the July-December period is any indication. Defense Secretary McElroy has revoked a two-month-old order that cut $170-million from R & D spending, and has relaxed the Pentagon's tight budget restrictions to the tune of $400-million for the July-December period. McElroy is still shooting for a $19-billion goal on January-June spending, but it is the first official acknowledgment that the $38-billion goal can be breached.

Big benefactors will be colleges and universities for research and development work, and prime and subcontract aircraft makers. Contractors will now be able to pass on to the government at least some, if not all, of the interest costs incurred by sticking to current production schedules while receiving smaller government payments.

Chances are that there may be other spending restrictions lifted when Congress returns in January, too. Hearings are already being scheduled to take a longer look at our military programs.

Lower prices in steel . . . .

. . . resulting from new competition in production may be in the cards. Rufus Easton of the Koppers Co., Pittsburgh, Pa., recently told a congressional subcommittee investigating steel prices that tests in producing four-inch square carbon steel billets by a continuous casting process has cut costs from $5 to $6 a ton.

Koppers is the sole licensee of a continuous casting process developed by a Germany company, and is building equipment for U. S. metals processors.

The method is being used in Europe and Canada, but so far no U. S. companies use it. One problem is that large size shapes can't yet be processed.

Easton thinks that the process may be perfected within another year, and once a major steel producer uses it others will follow suit. It eliminates several intermediate steps in open-hearth processing, thus should reduce both equipment and personnel costs.

Information on the burning rate of metals . . . .

. . . should be coming from the military before long. Army Ordnance is dickering now with companies to build a machine that will enable engineers to plot the burning rates of various metals. The idea is to get the machine, then experiment with different metals and alloys to see which ones will stand up under different heat conditions in simulated service.

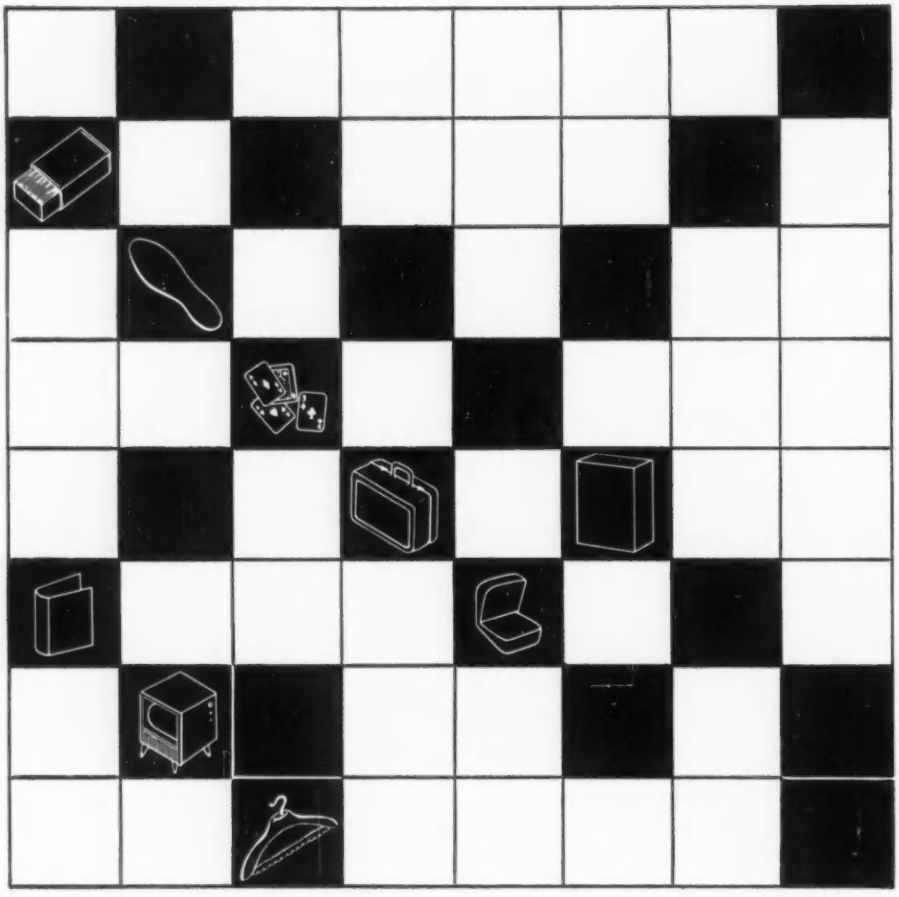
High-temperature-resistant metals are fast becoming the stumbling block for many of our top-priority defense programs—the nose cones for ballistic missiles, combustion chambers of aircraft engines burning the new chemical fuels, to name a couple.

Call the government for help in filling job vacancies . . . .

. . . the U. S. Employment Service (USES) and affiliated state employment security agencies recently put into operation a specialized placement service for such professional and managerial talent as engineers, scientists, accountants—in fact, just about the whole gamut of the high-ranking industrial skills that have been in short supply the past few years. State employment services have about 8,000 job openings for professional and managerial help.

78 special employment centers will operate as a professional network. Each office will have on file at all times a nationwide list of job openings in professional and managerial occupations. Applications of job seekers at any of the 1,750 local offices can be matched against the nationwide list of job opportunities.

Engineers bulk large on current lists. They show that employers have turned to the government employment services for help in locating 1,440 mechanical engineers, 1,208 electrical engineers, 447 aeronautical engineers (a 50% drop in this category since August), 231 chemical engineers, 161 chemists and 333 natural scientists, not elsewhere classified. Most of the aeronautical engineering job openings are in Maryland, Connecticut, Pennsylvania, California and Washington state.



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World-wide ...

DEVELOPMENTS TO WATCH...

Translations of Russian reports . . .

. . . and of contents lists of Russian publications are to be made available regularly through a cooperative program in Britain. Among those just published are technical articles on trends in development of machine tools, corrosion in welded stainless steel. Information may be obtained from The Secretary, Department of Scientific and Industrial Research, Charles House, London, S. W. 1, Eng.

Quick-response heat detector . . .

. . . being developed in England takes advantage of the special properties of one of the newer semiconductors, indium antimonide.

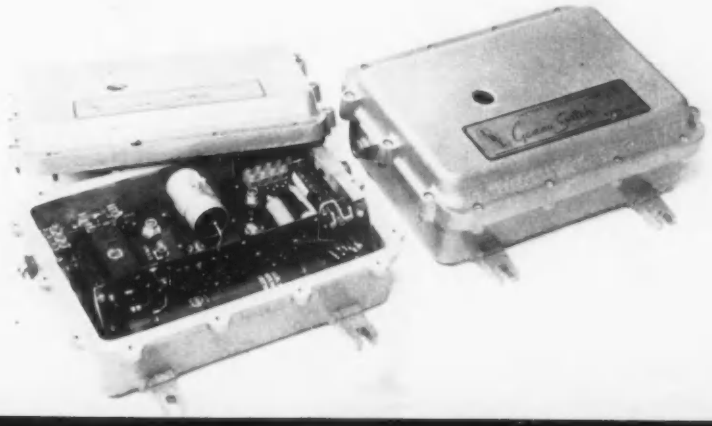
A number of materials will generate a voltage if light falls on them while they are in a magnetic field. With most this photo-electro-magnetic effect is too small to be of use. Not so with indium antimonide. Its effect is large enough to form basis of a "cheap and simple infrared photocell." The device, known as a PEM cell, has a tiny filament of indium antimonide supported in the gap of a miniature permanent magnet. Impedance is about 50 ohms; response time, 0.1 microsec; usable temperature range, 70 to 300 F.

Another new stainless steel . . .

. . . is announced in England. Firth-Vickers says its FV 520 is "the only austenitic steel which can be hardened by low temperature treatment," and claims it has both a high tensile strength and excellent resistance to corrosion. F-V also reports it can be welded without preheating, needs only stress relief at about 1020 F after welding. Composition: 16% Cr, 6% Ni, 0.07% C, 1.5% Cu, 1.5% Mo, 0.3% Ti. (For a note on another new British steel, this one aimed at the thermal barrier, see Nov. 4, p. 14).

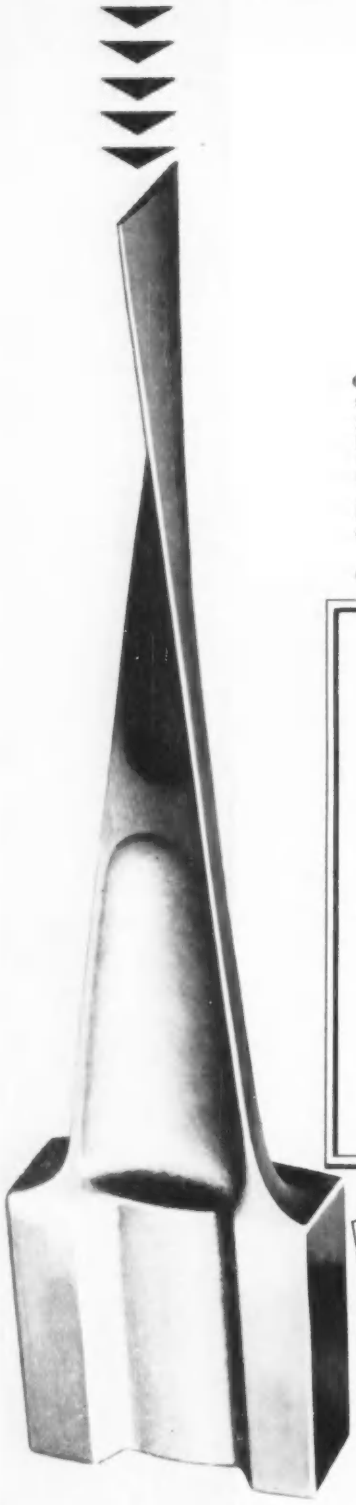
Isotope switch for level control . . .

. . . automatic counting, liquid-interface detection, and flow-failure indication is a modified, but far less expensive version of usual isotope-detecting devices. Designed by Isotope Developments, Ltd., Beenham Grange, Aldermaston Wharf, Berks., Eng., its halogen-quenched Geiger-Muller tube is in circuit with a simple relay. It has a printed circuit chassis, and can be wired into conventional control circuits (see photo). It is set to operate only when incoming radiation increases or decreases beyond a predetermined level. This on-off method does away with a continuous indication of changes, makes it possible to simplify the design and reduce cost. The company says it can be mounted on a hopper, and set to trip when radiation level of the contained material reaches a given point. A shutoff, warning light, or buzzer can then be activated. ID calls it the "Gamma Switch," says it has a sensitivity of 100 counts per sec for a radiation level (cobalt 60) of 1 milliroentgen per hour, can be set to trip at any count rate from 20 to 200 per sec. Response time can range from ½ to 16 sec.



British isotope switch is simplified device for complex jobs. It measures about 11½ by 11 by 4½ in., weighs only about 11 lb.

This from this through E.D.O.S.



. . . the story of a metalworking "end run" that skirts costly material and machining time . . . saves up to 70% on parts like this turbine blade

Contemplating use of titanium, stainless steel and other super alloy parts? Then you'll want to know about this unique process. It's E.D.O.S. — Engineered Designs for Optimum Structures — a method that puts all the metal to work . . . eliminates all or most machining . . . has been reported to save up to 70% on fabrication costs.

Basically, E.D.O.S. consists of precision forging and contour rolling plus flash or fusion welding.

And how successful, how proven is E.D.O.S.? The aircraft and related industries have been relying on it for years. Now it's being taken up by other industries as they go to harder-to-work, more expensive metals.

Why not get the facts and see how E.D.O.S. can play an important part in your products' success story.

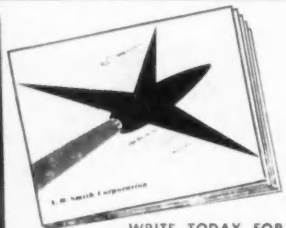
HERE'S HOW IT'S DONE

Original Type 403 Stainless Steel billet and fillout after initial forging operation.

Photo shows how forged piece is successively rolled out to blade's full length.

Basic blade is nearly 300% longer than size of original billet with minimum of trim and waste.

Finished blades, more than 100 per turbine, are delivered to the customer ready to be installed after simple root machining.



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Doppler guides planes, tracks Sputnik

As every youngster knows, a railroad train whistle always sounds higher as the train approaches, lower as it rolls away.

This pitch change, the Doppler effect, is an old and established principle but hasn't had very many practical uses. Now, though, scientists are putting it to work with a vengeance:

In tracking the Russian satellite, the change in frequency of the radio "beep" helped to indicate when the moonlet passed over a listening post.

And in air navigation, the Doppler effect provides basis for a remarkable series of radar systems that "determine true ground speed and drift angle, no matter how fast the aircraft travels." Signals are beamed to the ground, return as back-scatter or echoes, and are automatically measured for difference in frequency. True ground speed is then computed, taking into account the angle at which signal is beamed and timing of pulse.

Sometimes two, three or four beams are used for even more precise location, and to indicate wind drift as well as speed. "So accurate is the system," says the Air Research & Development Command, "that after a 1000-mile flight, aircraft will arrive within a circle 12 miles around the destination."

Six systems have been developed. Two are operational, (Aug. '56, p. 209) but these are heavy, bulky units. The four new ones coming up next year will be smaller, lighter, and considerably more effective.

Corrosion's problem No. 1

Pure water is a pure headache for designers of nuclear reactor equipment, and it's beginning to pose problems in other types of equipment as well. They're bad enough at normal temperatures, but when the operating temperature goes to 500 F, the situation gets really rough. It helps a good deal to keep oxygen content of the water low, particularly when wear is a problem. A study reported by N. B. Dewees of the Westinghouse Atomic Power Div. shows cobalt-based and stainless alloys showed 30% greater maximum specific wear index in oxygenated water at 500 F than in hydrogenated water with low oxygen content.

But controlling the water is only part answer. The problem of developing satisfactory materials still remains.

Fortunately, it's being found that alloying can help a good deal. Addition of small amounts of copper, nickel and iron to aluminum, for instance, form a surface film that helps to protect the base metal. Unfortunately, though, the film itself is rather easily broken in the alloy samples so far made.

A good many organizations are working on this problem, and it's slated to get plenty of attention at engineering meetings this winter, but a lot of work remains to be done before this problem can be labeled "solved."

briefs . . .

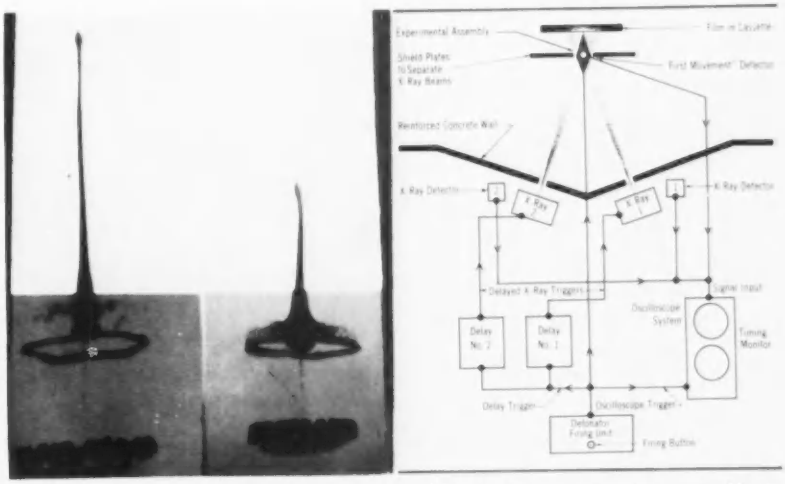
Broader temperature range for pH (alkalinity-acidity) reference samples is announced by National Bureau of Standards. Previously available for the range from 0 to 60 C, they can now be had in solutions useful to 95 C—a result of new determinations for the standard potential of the calibration cells.

Pre-flame reactions of air and hydrocarbons are being studied with a new technique—gas-liquid chromatography—at Ford Motor Company's Scientific Laboratory. W. A. Cannon reports that at least eight classes of compounds can be isolated by this method, and probably a good many more.

Flash x-rays pierce smoke and flame

Tenuous smoke particles can cause as much trouble as heavy steel plates when it comes to photographing explosions and combustion reactions. So, X-ray photography is being called in to help pierce the gloom.

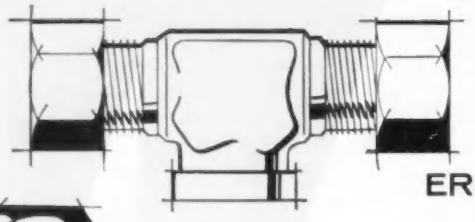
At Stanford Research Institute, a dual system is used—two x-ray tubes, set to take pictures at predetermined intervals, but simultaneously triggered by the explosion being studied. SRI is still working on the system—aiming for higher x-ray voltages and better control of exposures—but already "much valuable information is being obtained."

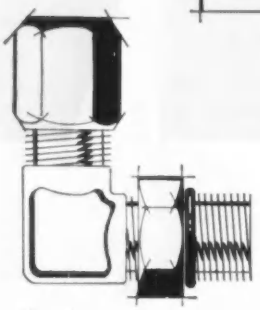


Explosion of shaped jet charge is photographed by dual x-ray system diagrammed here.

WEATHERHEAD

steel tube fittings for high-pressure applications





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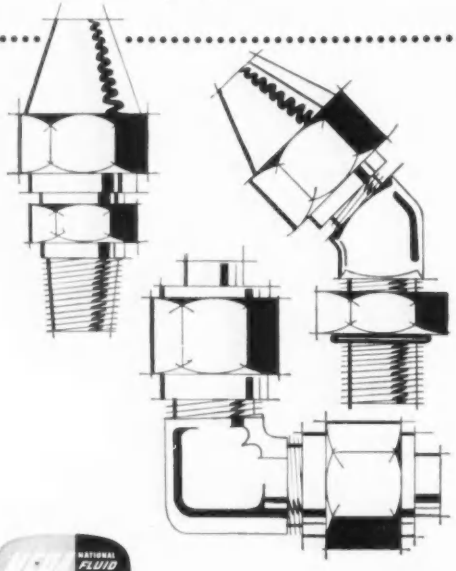
NOTE—All 7000 Series straight-thread Ermeto fittings and components have corrosion-resistant "Weathercote" finish.



FLARE-TWIN*

S.A.E. 37° Flare-Twin (J.I.C.) fittings are available with Dryseal-thread or with new straight-thread in popular styles and sizes for S.A.E. "O" ring boss design. Available with cadmium-plate or new corrosion-resistant Weathercote finish.

Trade name for the new Weatherhead 37° flared fitting.

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Rigid polyethylenes ready to roll

Until now, the rigid polyethylenes have had more names than applications. Called "linear," "high-density," or "low-pressure" polyethylene, or grouped under the broad term "polyolefins," they promised big advantages over the standard soft, waxy plastic used for squeeze bottles and housewares. But, it has taken time to make that promise come true.

Now, production plants are coming on stream, technical data is being assembled, and these new, stiffer, more heat-resistant materials are ready for commercial use. The fact that they do offer greater stiffness, heat resistance to about 250 F, plus useful electrical and chemical properties, opens up a good many design possibilities—bearings, gears, bushings, electron tube parts, and wheels like the one pictured here.

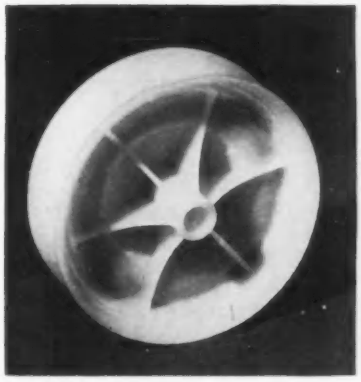
Will the new polyethylenes replace the standard type? For some applications, yes. But few in the industry expect them to take more than 30% of the established applications, and most set the figure at 15%.

What the new resins will do—and are doing—is take over some jobs now done by glass, metal, and wood, and give molded nylon a run for its money. Priced at 47¢ a lb, linear polyethylene is not as rigid, tough, or heat resistant as nylon, but good enough in all those respects for many jobs—and at about a third the price.

Companies like Reiss Mfg. Corp. are turning from nylon to linear polyethylene for furniture drawer rollers; Delaware Barrel & Drum is using it for spigots; other companies are testing it for everything from speedometer gears to protective grilles. It won't be just a competitor for nylon, though. The two can work together in many cases, as they do in the mower wheel.

However, it's not all sunshine for this plastic. As R.S. Aries and David Dworkin of Aries Associates point out, its superior high-temperature properties should extend the operating range of wire and cable. But problems in stress cracking and antioxidant performance at these temperatures remain to be solved. Too, while a few vacuum-formed parts have been produced, little technical data is available on this score.

Another point deserves mention: irradiation. It was thought that, because linear polyethylene was so much improved in heat resistance, there would be no further need to irradiate the material for electrical use. This may turn out to be wrong on at least three counts. First, irradiated low-density polyethylene stands about 100 F more than the high-density type. Second, irradiation treatment, applied to the newer types, may bring even greater improvement. Third, irradiation offers other advantages, notably in reducing stress cracking and permitting a higher level of pigment loading, and may well be worth investigating on these scores.



Polyethylene wheel, shown with molded nylon insert, is now going into production. Made of Phillips' Marlex it's used on power mower, takes standard rubber tire.

More data on foamed metals

Cellular aluminum, magnesium, titanium and other metals move closer to commercial use as new information is obtained on their properties, and production methods are improved.

Bjorksten Research Laboratories, which has been working on these materials for some time, now reports that tensile and compression strength, of foamed aluminum at least, are roughly proportionate to weight of the foam. If ingot aluminum weighing 170 lb/cu ft and with a strength of 30,000 psi is expanded into foam weighing 17 lb/cu ft, its strength will be near 3000 psi (actually, about 10 to 20% less). However, as the foam is compressed, it gains strength even though it retains its cellular structure. At 34 lb/cu ft, its strength is more than 6000 psi.

New applications are also in sight for such foams.

They are to be tested in sandwich panels for aircraft use, a primary reason for their development. But Bjorksten believes they may also find application as floats for liquid level control (in carburetors and chemical processing tanks, for instance), as paneling for mobile equipment, and as material for marine parts. The foams can now be made in either closed-cell (water-resistant) or open-cell (sponge) form and in densities from 12 lb/cu ft up. Rigidity is excellent, and the foam can be press-formed into sheets having varying curvature on two sides and non-uniform variations in thickness.

briefs . . .

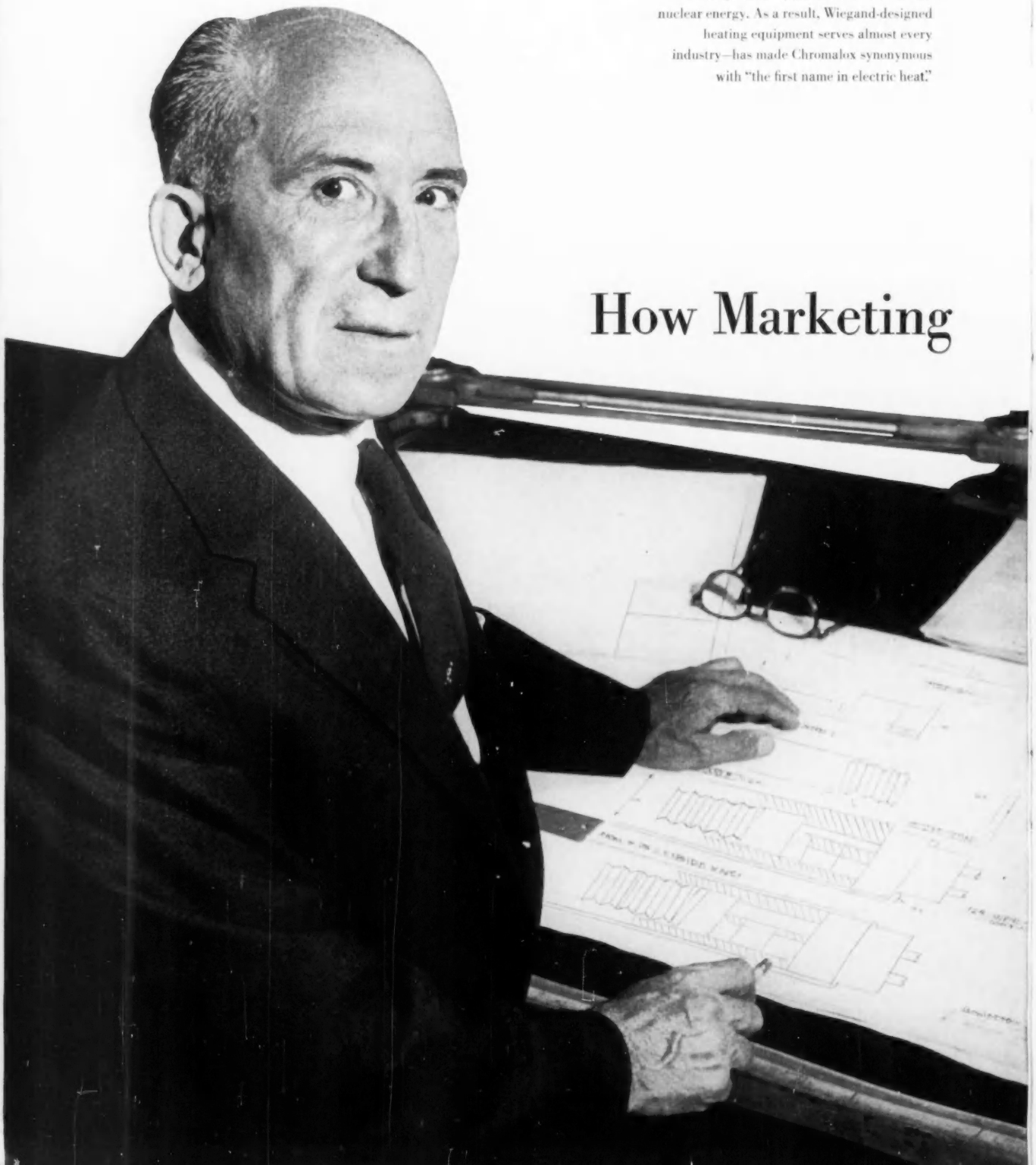
Zirconium sponge is now coming from Columbia-National's plant on a tonnage basis. This is commercial-grade zirconium (hafnium content, 2%) for industrial use. Reactor-grade material is to be made in the same plant, but shipments have not yet begun.

New synthetic fiber may be produced by Standard Oil of California. Its research subsidiary, California Research Corp., is working on a "nylon-type" fiber said to be strong, dyeable, and resilient. Promising applications: tire cord, rug fabrics.

Dupont's new acetal resin, *Delrin*, is slated for commercial production in 1959. A plant site has been selected, and construction starts immediately. The plastic—tough, hard, and heat-resistant—is already under test for machine parts, electrical components and appliances.

As Edwin L. Wiegand Company's Engineering Vice President, Mr. Joseph J. McOrlly starts with any one of more than 15,000 versions of the famous Chromalox heating element, and designs equipment to handle any kind of heating problem, from domestic hot water to complicated applications in the field of nuclear energy. As a result, Wiegand-designed heating equipment serves almost every industry—has made Chromalox synonymous with "the first name in electric heat."

How Marketing



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Vice President in Charge of Engineering
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This year the catalogs of 1,740 manufacturers are available to America's building and product designers, plant engineers, and metalworking production executives in one or more of the six pre-filed catalog collections which Sweet's maintains for these manufacturers in the offices of qualified buyers throughout the United States.

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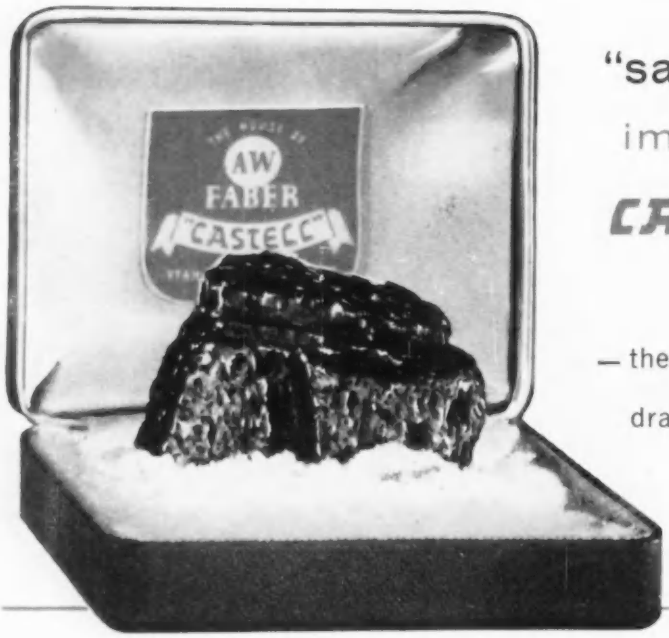

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STEP TAKEN, STEPS TO TAKE...

President Eisenhower's appointment of a White House special assistant on science and technology is a sound and badly needed step, taken at a crucial time. Sputniks I and II stirred the free world as nothing else has, at long last awakening public consciousness to the stark fact that war has moved out of the trenches of World War I, through the production shops of World War II, into the laboratories. James R. Killian, Jr., educated as a scientist and with Massachusetts Institute of Technology ever since his graduation in 1926, represents a happy choice. The public and the President have confidence in him and his college. He knows science and engineering, has had extensive experience with research, with administration, and with the military. He can assemble a control committee that will get things done.

The way is now clear to end inter-service rivalry, to concentrate effort on the missiles or other weapons with best potential, to enlist public support of a crash development program—and perhaps to explain to the layman why money alone isn't the answer in research and development, why we cannot attain immediate results merely by spending another billion or by pushing a button.

Dr. Killian can do much to explain **why** discovery takes time, **what** money and equipment can and cannot accomplish, **how** basic research can be encouraged. Midway between the public and the ivory towers of science, he can understand both, and interpret each to the other. He can reduce the swings of the pendulum of public opinion from satisfied complacency to startled disillusionment and criticism.

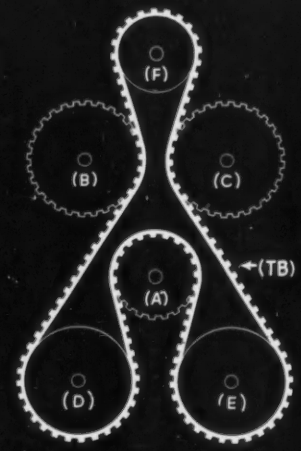
We, too, have our job to do now. It is up to every scientist and engineer to seize the opportunity presented by this recognition of our capabilities, to show what the technical mind can accomplish when free of the bonds of red tape and politics, of tradition and procedure. The vital "next step" is now squarely up to us.

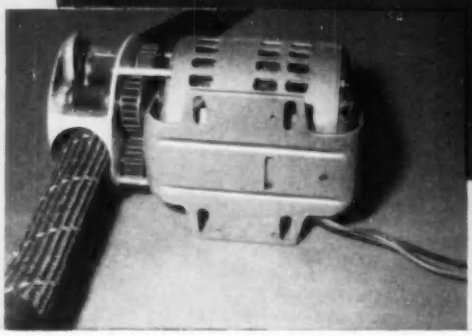
PowerGrip "TIMING" BELTS

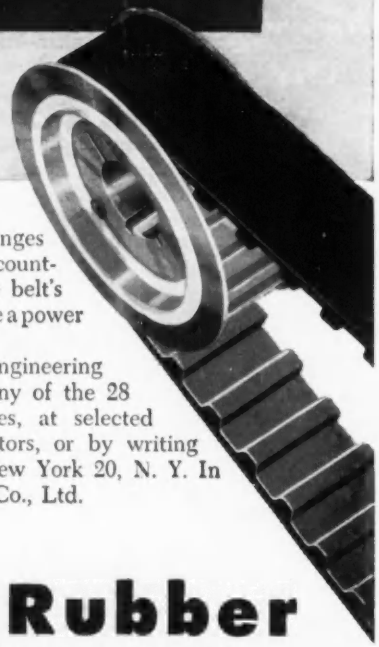
"Here's how to make a vacuum cleaner disappear or appear... all by itself," says "GRIP" POWERS

In this schematic of the hose retraction and extension mechanism of the EasyWay Vacuum Cleaner,* the 12-groove drive pulley (A) is powered by a ¼ h.p., 1750 r.p.m. electric motor. The power is transmitted—*through a single U.S. PowerGrip "Timing" Belt (T-B)*—to four pulleys. Two of these (B & C) are 26-groove "Timing" Belt pulleys which are positively engaged by the teeth of the belt. The other two (D & E) are flat pulleys, which are driven by the friction surface on the back of the belt. A small flat belt pulley idler (F) provides adjustment and more wrap around the four driven pulleys. These four pulleys, in turn, drive four specially molded U. S. Rubber rollers located on the other side of the plate. The rollers, by rotating, drive the hose (also made by U. S. Rubber) either in or out, as required.

*Manufactured by Simplon Corp., Dearborn, Mich.







"Grip" Powers is holding the "business end" of one of the most modern home appliances—a vacuum cleaner, built into the wall, with hose that extends or retracts *completely automatically.*

This cleaner can literally "put itself away," thanks to the U. S. PowerGrip "Timing"® Belt drive on the hose retraction mechanism (pictured above.) Because of PowerGrip's near-100% efficiency, the manufacturer was able to combine simplicity of design with exact response to constant changes in tension. This is just one of countless examples of this unique belt's ability to simplify and improve a power transmission unit.

These belts, plus expert engineering service, are obtainable at any of the 28 "U. S." District Sales Offices, at selected power transmission distributors, or by writing us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

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Industry Makes Room for R&D

A little more than a year ago, General Motors opened the doors of its ultra-modern research and technical center, a multi-building facility that cost $100 million. Today, the host of scientists and engineers working in GM's pryramiding projects needs more room. It's likely that GM will spend more millions to meet this need.

Like many another US industrial firm, GM must yield to the pressures of progress. This means a continuing expansion or R & D facilities manned with scientific talent. The goal; new product design.

This continuing expansion is not new. Since 1950, industry has realized the need for R & D, and has generously ladled funds to sate the appetite of an increasingly hungry product market—military and civilian.

But recent defense budget cutbacks and a clouding business horizon have given rise to fears that a still-hungry market may be on the verge of getting up from the table. Experts are predicting that industry will spend 7% less in 1958 on new plants and equipment (see page 25).

Yet, spending for R & D buildings and equipment continues to soar; particularly in nucleonics, electronics, chemicals, aircraft, petroleum, and rubber. A spot-check around the nation by Product Engineering correspondents shows a lot of faith in R & D as the lifeblood of a prosperous economy:

WEST COAST

Los Angeles Chamber of Commerce estimates that 40% of the $1 billion to be spent on industrial expansion next year will be allocated to R & D. In an area report, yet to be released, the Chamber said that defense cutbacks and uncertain business conditions have not hurt R & D budgets of leading companies in the Los Angeles area.

Convair Div., General Dynamics Corp., is investing $20 million in a new astronautics building, with USAF adding a similar amount to equip the installation. Convair is providing John Jay Hopkins Laboratory of Pure and Applied Science with another $10 million to study industrial applications of atomic power.

Bendix-Pacific has just completed a $3-million research installation, will spend another $500,000 to equip it in 1958. Beckman Instruments' new $1.5-million research and engineering center in Fullerton will service Beckman's scientific and process instrument division.

Aeroneutronics, Inc., recently created division of Ford Motor Co., is scheduled to build a multi-million-dollar research and engineering installation in Newport. Litton Industries, Inc., is expanding research facilities at a rate of $1 million annually.

Union Oil Co. has invested more than $5 million researching shale-oil extraction, and will spend another $300,000 to investigate extraction of oil from tar sands.

In the San Francisco area, the California Research Corp. subsidiary of Standard Oil Co. has just invested $2 million in petrochemical research. General Electric's microwave lab in Palo Alto, already a recent $2-million, investment, is soon to be expanded considerably. GE's Vallecitos Atomic Power Lab, near Pleasanton, was expanded by dint of a $4-million nuclear research reactor. (See page 26.)

Lockheed Aircraft will increase its R & D investment at the Palo Alto and Sunnyvale installations to $20 million. Some 900,000 sq ft of floor space is being built, 240,000 of it for the Palo Alto lab. Also new at Palo Alto is Kaiser Aircraft's $300,000 electronics lab.

Shell Oil Co. is putting the finishing touches on a $10-million research expansion program centered mainly in Emeryville, Calif., but including Houston, Tex., and Modesto, Calif. The three-year expansion program is keyed mainly to the needs of Shell's oil and chemical divisions.

Hoffman Electronics Corp., Los Angeles, has just dedicated a new research and development center seeking faster communications, better airways, jamproof navigational systems, and long-distance radar.

SOUTHWEST

In the Phoenix, Arizona area, some $25 million is being spent to expand R & D facilities. Motorola's research lab is spending $2.5 million to improve its ability to produce guided missile components. Goodyear Aircraft will spend $1 million researching missile guidance devices within the next year. Air Research Div., Garrett Corp., is committed to spending $4.5 million in expansion of R & D facilities in connection with developing electronics packages for aircraft.

GE has installed a $1 million research center at nearby Arizona State College. Hughes Aircraft at Tucson, developing the Falcon missile, admitted to multi-million-dollar expansions but declined to discuss further.

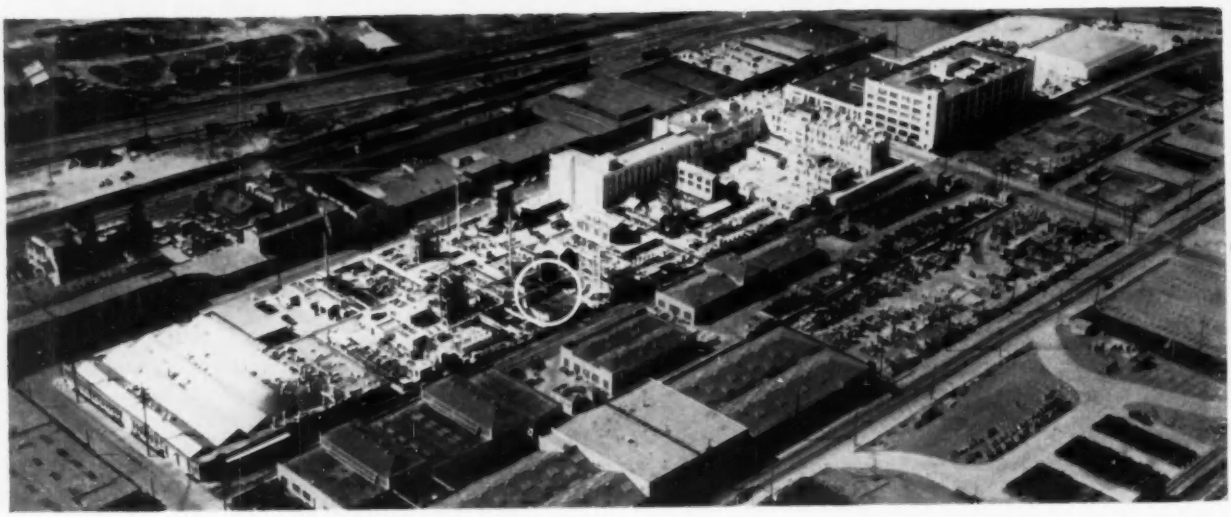
In the Dallas area, Chance Vought has scheduled completion of a $3.8-million Mach 5 wind tunnel by next

Related Statistics Prove Growth of Industry R & D

In 1953 U. S. industry spent $3.7 billion for research and development. This year $7.3 billion, almost double the 1953 amount, will go for R & D. And, according to a McGraw-Hill Economics Dept forecast, $9.3 billion will be spent in 1960; 40% for new buildings, equipment.

Back in 1920 there were 290 industrial research laboratories. Last year the National Research Council listed 4,834 such R & D installations—a 1600% increase over the 37-year period.

The significance of R & D to the nation's industry is pointed up by growth percentage figures for the various divisions of industry during the 1945-55 period. Aluminum has registered a 425% growth increase, chemicals up 260%; instruments, 420%; electronics and electrical parts, 415%; natural gas, 231%; paper, 160%; steel, 142%.



Setting for a portrait . . .
of R&D expansion is the Emeryville, Calif. facilities of Shell Oil Co, doubled in size every 10 years since 1928. Lightened area running diagonally across photo shows how $7-million expansion program spawned more than 12 buildings and considerable equipment.

summer. A leading instrument manufacturer is planning a new research center to improve existing development facilities and institute new lines of product design. Temco Aircraft is building a $59,000 antenna testing lab and has just completed a 100,000-sq-ft engineering center. Convair has completed a new hydraulic and pneumatic-pressure-test building and will soon finish a high-altitude test chamber. Collins Radio is building a $1.7-million R & D building near Dallas. The new facility will double the space available to its scientists and engineers.

Colorado Research Corp., near Denver, will build a $200,000 research center. Boulder Div., Beech Aircraft Corp., has just opened a $350,000 research lab. Included in Ramo-Wooldridge's new $5-million plant outside Denver will be a substantial research facility. Sundstrand-Denver, subsidiary of Sundstrand Machine Tool, has completed a $250,000 R & D installation. Ball Bros. Co., has opened a $150,000 lab to conduct fundamental applied research in electronics and servo mechanisms.

Two other firms substantially enlarging their R & D facilities are Hathaway Instrument Div., Hamilton Watch Co. and the Heiland Research Division of Minneapolis-Honeywell Regulator Company.

MIDWEST

In the Cleveland area, Republic Steel Corp. is building a $3-million central research lab on a 40-acre tract. An $8-million addition to B. F. Goodrich's R & D facilities at Avon Lake outside Cleveland was only recently completed. It will be devoted to developing polyvinyl resins and plastic compounds.

Also in Cleveland the Glidden Paint Co. has opened a $400,000 research and development center. Thompson Products Inc. is building a multi-million-dollar R & D center on a 25-acre site across from its Tapco plant. In Toledo, Ohio, Champion Spark Plug has begun construction of a $1-million engineering and research center.

In Dearborn, Mich., Ford's massive, $150-million R & D center, with some 3.5 million sq ft of floor space will be ready in mid-1958. Chrysler Corp. has purchased 1,700 acres in a Detroit suburban area, ostensibly for expansion of R & D facilities. Bendix Aviation is spending $1-million for a research lab, while Michigan Tool Research Center is spending a like amount for additional facilities.

EASTERN SEABOARD

American Machine & Foundry plans to spend $2.1-million expanding its R & D facilities during the next three years. Bulk of AMF research is done in Stamford, Conn. and Chicago. GE's Silicone Products Dept. in Waterford, N. Y., will spend nearly $3-million increasing its research operations between now and the end of 1958. A spokesman in N. Y. explained that on a corporate level GE management invests more than 6% of its annual sales dollar in research and development, during past 10 years has spent $240 million for R & D facilities.

At Amherst, N. Y., Sylvania Electric has opened an electronics and development center providing 100,000 sq ft of floor space, that cost several million dollars. Sylvania has also added a $1-million wing to its Bayside, N. Y. research center. In Wayne, N. J., U. S. Rubber recently dedicated facilities described as part of a $125-million research and development program being undertaken by the company and its 22 plants in the U. S. and Canada.

Some 11 leading companies, led by AMF, are constructing a swimming-pool-type reactor at Plainsboro, N. J. for atomic research. Bell Telephone Laboratories is building a cyclotron at Whippany, N. J. Both are multi-million-dollar projects.

Construction of a research and engineering laboratory on a 650-acre tract has been started by Esso Oil Co.

Public Must Understand Science Before U. S. Wins 'War of Labs'

CHICAGO—The scarcity of people who understand science and engineering—and how their lives are affected thereby—may well be America's greatest "technological shortage." This lack of scientific consciousness by the country's millions of non-scientists could well be the missing ingredient in our silent battle between the laboratories of the world.

This was one of several basic conclusions reached by some of America's top scientists at the "Conference on Engineering & Scientific Education—Foundation of National Strength," jointly sponsored here Oct. 31 to Nov. 2 by the Engineers Joint Council, National Academy of Sciences, National Science Foundation, Scientific Manpower Commission, and the Western Society of Engineers.

"A much heavier emphasis on scientific subjects at all levels in our educational system would be helpful, even though the students in such cases do not intend to specialize in technical fields," said Dr. M. H. Trytten of the National Research Council. "The rapid increase in technical control of the functions of personnel in many fields should mean that they would be more effective had they had more familiarity with the scientific and technical backgrounds of their activities . . . including politics, business, and human relations."

Conference keynoter Dr. Lee A. DuBridge, president of California Institute of Technology, called attention to the fact that: "One brilliant scientist or engineer may turn up with more ideas than 100 ordinary men. He may, in fact, need the help of the 100 in putting his ideas to use. Hence, while we are educating the hundred, we should not fail to find and encourage and give special attention to the one. Since we cannot always pick out 'the one' at an early age, we must provide opportunities for the many, too . . . We may by 1972 have to spend twice as much for higher education as we do for cigarettes! . . . Certain quarters of industry and government have become so absorbed in numbers that they have forgotten quality. There is a danger that the public has been given the impression that engineers can be counted up just like ditch diggers; to dig twice as many ditches, just hire twice as many diggers."

Dr. Wm. H. Miernyk of Northeastern University again blasted the Bland-Stigler report that there is no shortage of engineers (Sept. 9, '57, p 33), pointing out its wrong basic premises. He said engineering enrollment, 248,733 last year, is expected to increase 66.4% by 1966-67; graduate engineering enrollment, 25,927 last year, will jump 96% in the same period. Present engineering teacher shortage is 14%; requirements in 10 years are for 9,500 new teachers—more than the present total of 9,078.

Yale University's Dr. John S. Nicholas, president, Scientific Manpower Commission, suggested two things, the "virtually untapped resource, woman power," and a cabinet post to coordinate education, industry and government. He expects "even Harvard" to have 25% women in five years, and their employment on an equal and competitive basis. He sees a need to stress the peaceful side of science, rather than the terrible, and to cut sharply the time wasted in useless courses in secondary schools. Too little science and mathematics is offered.

Dean Gordon B. Carson of Ohio State shed some light on this situation. In mathematics placement exams at OSU last year, he reported, engineering freshmen scored 81%, arts & science frosh 35%, primary teachers 20%. This automatically results in a bias against mathematics in the minds of teachers which will be passed on to students—with poor training in the subject as well. He also reported that in 1951, there were 586 doctorates awarded in engineering in 1951, only 610 in 1956—far too low a rate of increase considering our needs for specialists and for educators.

Many speakers stressed waste of scientist and engineer time doing work that could be handled by technicians, both in colleges and in industry. Said Dr. Nicholas, "University research requires leisure to think." Said Dr. Millet of Miami University, "All students cannot be geniuses. . . ." Said Dr. J. C. Warner, president of Carnegie Institute, "Two halfwits do not make a wit."

Other points of interest: Dr. E. S. Hiscocks of the U. K. Scientific Mission, said "Science in Britain is not quite as a respectable profession." Said Dr. Warner (sic): "We have too much interest in more butter than in more guns, more interest in fins than in education and research." Reported by Dr. Carson (sic) as the statement of a high-school math teacher back for a brushup course, "It's the first time I've known where algebra is used." Laird Bell reported industry gifts to colleges in 1953 were $800,000, last year were $6,000,000 from 12,410 companies.

New Plants off in '58

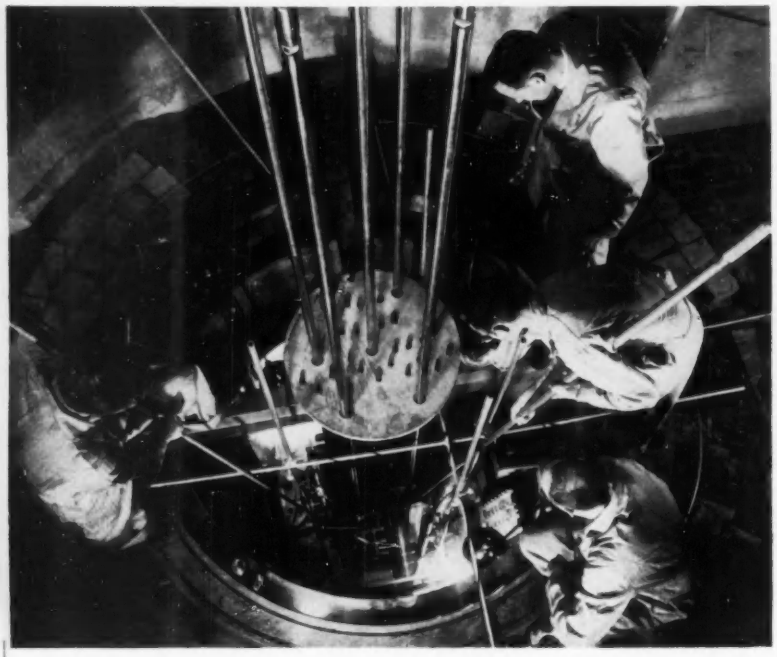
NEW YORK—American industry will spend 7% less on new plant and equipment in 1958 than this year. And spending in '59 will stabilize at the lower level. These key findings by the McGraw-Hill Department of Economics sum up a crucial sector of the economy.

Spending for all classes of business—mining, railroads, utilities, petroleum, commercial and manufacturing—is scheduled at $36.1 billion for '58 compared with $38.6 billion this year. Manufacturing industries will spend $11.6 billion next year against $13.9 billion this year.

But this does not mean a cut in engineering for new products and product improvement. All but 5% of the firms surveyed will spend as much or more on research and development next year—57% will spend at this year's rate; 38% will increase R & D spending.

Research expenditures will rise most sharply in the chemical, paper, rubber and electrical equipment industries. The largest research cut will show in aircraft where 27% of the companies indicate they will pare budgets.

Will continuing investment in research mean more plant construction after 1959? It will for 38% of the firms surveyed—at least they expect it to—but not for the remaining 62%. New plant needs growing out of current research are reported by industry this way: rubber (91% of companies surveyed), chemicals (65% of companies), electrical equipment (60% of companies), professional and scientific instruments (59% of companies), aircraft and parts (50% of companies), and petroleum products (50% of companies.



Nuclear fuel tank . . .

fully-enriched, plate type fuel elements containing U-235 are set deep inside the steel reactor vessel at GE's Vallecitos, Calif., atomic power plant. Slender rods extending above the nuclear fuel tank control amount of heat produced.

First Privately-owned Atomic Power Plant Exceeds Designer's Fondest Dreams

PLEASANTON, CALIF.—General Electric's recently unveiled Vallecitos Atomic Power Plant, first in a series of privately-financed atomic-power projects, far exceeds its designer's expectations in terms of economy, maximum output, and ease of installation.

The reactor, a direct-boiling type using light water as moderator and coolant, will be capable of operating at more than the 5,000 kw, and with total thermal output of far more than the 20,000 kw, for which it was licensed by the Atomic Energy Commission. GE is expected to apply to the AEC for permission to operate at a higher capacity.

According to Samuel Untermeyer, designer of the dual-cycle reactor, and manager of Vallecitos reactor operations, none of the usual difficulties arose during installation. He said power is far more stable than anticipated and operation is as "smooth as silk." Although Untermeyer and his staff admit they can't explain this smooth sailing, they aim to find out.

Reactor core is housed in a steel pressure vessel, 7 ft ID and 20 ft high with 3⅜-in. thick walls. Core is made up of more than 100 stainless steel clad, fully enriched plate type fuel elements containing about 23 kg of U-235.

Water enters the bottom of the pressure vessel and is heated as it rises through the core. The reactor can be operated either with natural circulation, using the buoyancy of steam to move the coolant through the core, or with forced circulation, using a large pump to force water and steam through the reactor. Operating pressure is 1000 psi (exceeding 600 psi, a previous reactor-high). Steam temperature is 545 F.

The reactor is controlled by rods of boron that absorb neutrons and prevent uranium atoms (enclosed in stainless steel sheets) from splitting. Amount of steam produced is regulated by adjusting position of control rods. To shut down plant, rods are fully inserted in core.

Once generated, steam rises to top of vessel for transfer to a conventional turbine generator. Spent steam from generator is led through a condensor. The water is returned to the reactor pressure vessel. Direct connection between reactor and turbine eliminates costly heat exchangers.

The entire reactor is housed in the lower portion of a dome shaped steel containment vessel, 48 ft ID and 100 ft high. It is surrounded by 8-ft-high concrete shielding with an upper shield of steel weighing 80 tons.

The GE reactor powers the Vallecitos generator installation of Pacific Gas & Electric Co., co-sponsors, co-builders and co-owners of the plant with GE.

• • •

SAN FRANCISCO—The California Public Utilities Commission has ruled that expenses incurred in developing nuclear power as a means of generating electricity can be charged by a utility to operating expenses. The commission ruling stemmed from a case involving Pacific Gas & Electric Co., although no one had challenged PG&E's right to so charge its Vallecito power plant costs.

She's trim, frisky . . . and only 9 ft, 8 in. long, 4 ft, 9 in. high, referring to Meadows Friskysport car, shown at London's International Motor show. Frisky is Britain's answer to the bubble car.

Rate British Auto Show Dull—But Sporty

LONDON—Highlighted only by the unusual range of sports cars that regained Britain her lead as world's largest auto exporter, the international motor show here, technically speaking, was one of the dullest ever staged.

Only outstandingly new item was the Motor Industries Research Association's automatic, infinitely variable, hydro-mechanical gear box. Revolutionary and inexpensive, the box is far from full production status.

In the ultra-light car bracket, the Meadows "Frisky" made its debut as the only thoroughly-engineered challenge to the rumbling bubble car sweeping in from Europe. The "Frisky" has a tubular steel frame with a stressed, laminated plastic body. The ladder-type tubular frame uses diameter tubing throughout, and meets stress differentials by varying the gage.

The "Frisky" engine is a standard, twin-cylinder motorcycle unit integral with gear box and mounted midships. Drive is direct through chain to a single "live" tube axle. Because rear wheel track is only 2½ ft, there is no differential, and only one of the rear wheels is braked. Front suspension is equipped with a Dubonnet-type torsion-bar springing, with rubber in torsion serving as springing agent. Its 325-cc engine produces 18 bhp.

Disk braking was confined largely to front wheels of sport cars. Two-pedal control, while inexpensive, still isn't standard on any models. First application of electromagnetic clutch, only recently announced, will be built into the British-made Issetta bubble car. Its design utilizes a magnetic-powder coupling that stiffens with current, offering progressive torque take-up. Gears are chosen manually, but clutch operation is achieved with an electrical switch gripped by the gear lever.

Aimed at dampening road noise, Humber and Vauxhall models featured front suspensions and steering linkages mounted from separate cross-members, and insulated from car body by thick rubber cushions. Use of offset gudgeon pins to reduce piston slap was demonstrated.

Outstanding accessory item was Britain's first automobile air-conditioning equipment. Heat extraction rate is equivalent to heat input of a 3 kw heater. Airflow is approximately 200 cu fpm, of which only one-third is recirculated, assisting humidification control of the flow. System is based on vapor-compression principle, and embodies engine-driven compressor, evaporator, condenser, throttling-gear, temperature-control equipment, and separate heating system.

Case History: R&D Triples Profit

MONTREAL—Five years ago Canada Iron Foundries, Ltd., the Dominion's largest, was a sleeping giant. No research and development; little or no technical control. Today, thanks to a full-blown R & D program, CIF has increased its profit statement by more than 300% since 1952, and faces a highly competitive future with technical assurance.

This industrial reawakening began when T. F. Rahilly assumed the presidency of CIF—which was then a small group of foundries. He promptly embarked on an expansion program, buying and building; CIF now is the parent nucleus of 10 operating iron foundries, two machine shops, and plants manufacturing structural steel, concrete pipes and electric motors, among other products.

To capitalize on this expansion, Rahilly was convinced of the need for a technical R & D program. First step: company-wide survey of production methods to determine adequacy of techniques in relation to costs.

Plant metallurgists were assigned. Control labs were created. Figures show that for every dollar spent, $8

returned. In time the technical-control problem was solved; supervision of production processes became routine. Attention was now turned to the research aspect.

Technology director J. Edward Rehder approached his R & D problems along three avenues; administrative, recruiting and facility-wise. A chief metallurgist, chief inspector, and research director formed nucleus of his staff. Design engineering talent was ardently wooed. A large, well-equipped research lab has been built in Montreal—more coming.

A major CIF problem was the declining markets for its standard products. Iron railway wheels were being replaced by steel wheels, so on the recommendation of CIF design engineers a $7,000,000 cast steel wheel fabrication plant was ordered. The research staff was charged with determining what substitutions could be made for other products experiencing decreasing demand.

The manufacture of Devalaud pipes has undergone substantial changes too. It once took 40 min to change a mold; redesigning has made this possible in 10 min. A newly designed rubber-sealed joint for such pipe is less expensive, permits faster pipe-laying. Still in experimental stage is a glass-lined cast iron pipe with cost of manufacture a sole deterrent.

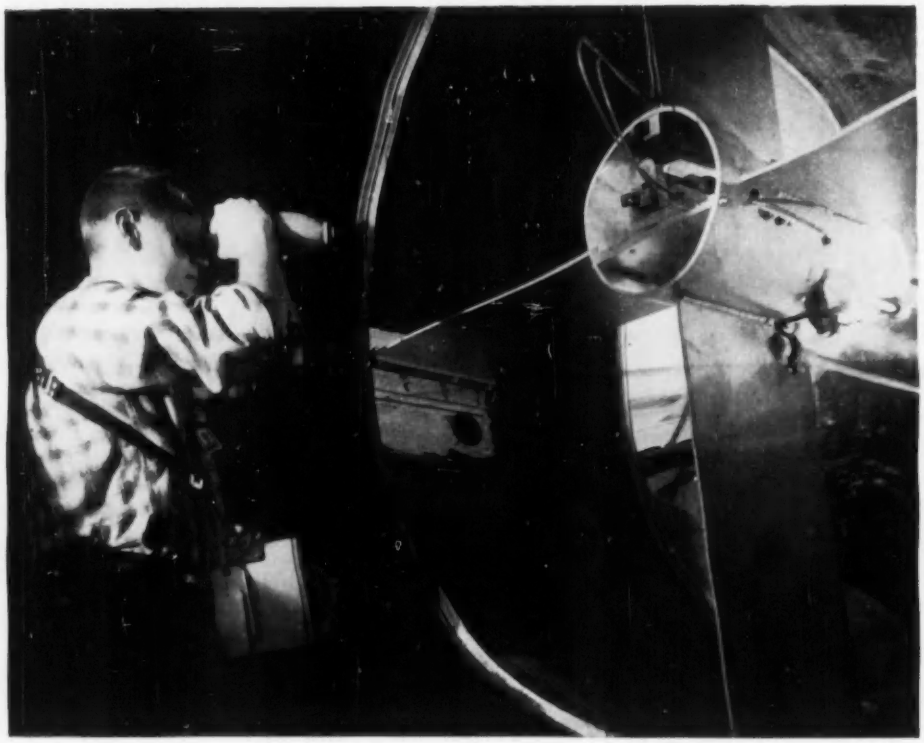
Finishing touches have recently been applied to these matters:

• Carbon injection. Powdered carbon is injected into the molten iron to adjust iron composition. Result: better control, lower cost cupola charge, higher impact strength.

• Water-cooled, hot-blast cupola. Nonrefractory, this cupola is processed with either basic or acid slag. Not restricted to good cast iron scrap or pig iron, it can be adjusted to handle 100% steel scrap.

• Waste gases from pipe-annealing furnaces are used in hot blast for cupolas.

Besides using CIF engineers for redesign, Pres. Rahilly obtained services of a top New York research consulting firm to set up a formal five-year program that will serve as progress timetable. CIF management knows that R & D is never-ending; that mandatory continuity is its chief asset.



Cooking by searchlight . . .

technician checks temperature at heart of GE's converted army searchlight that reaches 5000 F by itself, 6000 F on sun's rays. Several features improve "cooking": a quartz chamber that can be evacuated to test specimens in a vacuum and a leeway to fill the chamber with mixtures of gases to resemble any desired atmospheric condition. Temperatures of 5000 F are reached using searchlight candlepower for heat source. When heating to 6000 F by sunlight, heliostat automatically tracks and directs the sun's rays into its focusing lens. On cloudy days, the furnace is operated indoors using searchlight candlepower substitute. Because the furnace temperatures are relatively low for work in many high-temperature areas, GE Aerosciences engineers use fluid-stabilized arcs, shock tunnels and other tools for added heat. Almost any phase of high-temperature research and development can be handled by GE. To check temperature in the heart of the furnace, technician uses pyrometer. Crossed beams at center, which form the "spider", shut out only about 3% of light entering the furnace.

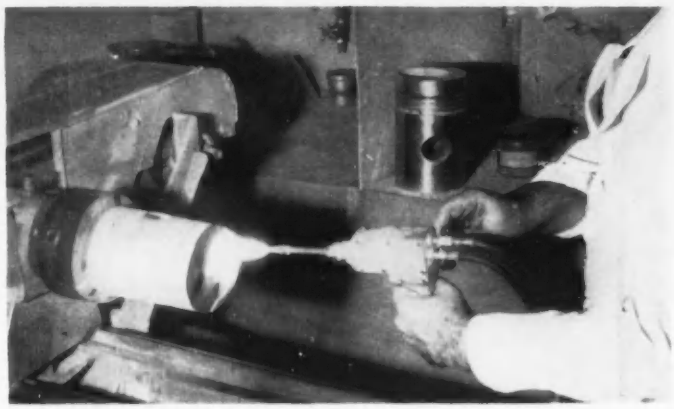
Ceramic Coating Offers New Hope in Struggle Against Exhaust Smog

CHICAGO—Armour Research Foundation scientists have developed a catalytic ceramic coating for piston heads that may significantly reduce carbon monoxide and unburned hydrocarbons in automobile exhaust gas. The coating also reportedly offers promise of thermal insulation, greater combustion efficiency, and more economical engine operation.

The new process stems from the Armour Research Foundation's earlier work in "flame ceramics," which indicated that ceramic coatings might reduce thermal cracking and carbon in diesel engines. A flame-sprayable coating was developed containing rare-earth oxides that acted as a catalyst in internal combustion engines.

In lab tests at the Armour research facility of the Illinois Institute of Technology, a standard automobile engine with "about half" of the top area of its pistons coated was run under idling, cruising, full acceleration and deceleration conditions with non-leaded gasoline and with air bled in at the carburetor intake. Comparing exhaust data from this investigation with that of an identical but "uncoated" engine disclosed that the coating decreased carbon monoxide and unburned hydrocarbon properties, particularly during acceleration and deceleration. While tests indicate this coating may significantly affect engine exhaust, researchers look to future development of a more active and stable coating for testing on both diesel and gasoline engines using leaded fuels.

The ARF development, one of a series by leading research groups studying the relationship between engine exhaust gases and the nationwide air-pollution problem, follows Ford Motor Co.'s discovery of a promising oxidation catalyst. Ford's candium pentoxide effectively eliminated more than 80% of offensive hydrocarbons in lab tests on a single-cylinder engine run the equivalent of 4000 miles. Ford also reports successful tests with automotive fuels using another newly discovered catalyst, vanadium pentoxide, a uranium byproduct. A plentiful supply of this chemical makes development of a practical anti-smog automotive exhaust device look more economically attractive than ever before, according to Eugene F. Hill of the Ford Scientific Lab. He points out that while it is much too early to estimate, it is now conceivable that a reasonably priced device might be designed. This could be a container of ordinary steel acting as a "converter" installation using vanadium pentoxide. The device would be located near the engine so that hot exhaust gas would be obtained quickly.



Flame spray ceramics . . .
process, developed at Armour Research Foundation, applies protective coating to top of diesel engine piston.

Bits and Pieces

By Dec. 31, employment at Lockheed's Calif. Div. will be reduced 5,000 from present 29,000, thanks to military procurement economies. It may even drop to 17,000 by the end of 1958 . . . National Society of Professional Engineers decrying efforts by leaders of industry to increase supply of engineers. They say emphasis should be on quality, not quantity, adding that much engineering talent is wasted at levels below capability . . .

IONS IN THE FIRE

"An ion rocket engine can be built and operated, one that can be taken to the fringe of space in the nose of a rocket, then fired," says C. W. Guy, asst. gen. mgr at Rocketdyne. "Such an engine would offer an immediate extension of satellite programming, for reconnoitering the solar system." . . . Storing images for prolonged viewing is possible with an electronic storage display panel developed by RCA. The bright image persists for several minutes after an exposure of only 1/100th of a second. The panel is a sandwich formed by a thin layer of cadmium selenide photoconductor on one side, and a layer of electroluminescent material on the other, separated by a thin layer of opaque material . . .

HIRE AND HIGHER

Salary levels of engineering, scientific, and administrative employees rose an average of 5.9% between June 1956–57, according to a survey just made by the AMA. This increase is lower than the 8.6% average salary increase reported for the same group for the year ending June, 1956. . . . After 10 years of producing solely for government military branches, Republic Aviation Corp., Long Island, is making a bid for commercial diversification, seeking work in machining, turning, resistance and flash welding, fabrication of parts, stretch forming, hot forming, assembly, tool and die making, stamping and fusion, and electrical and electronic design and assembly.

How to Select and Apply

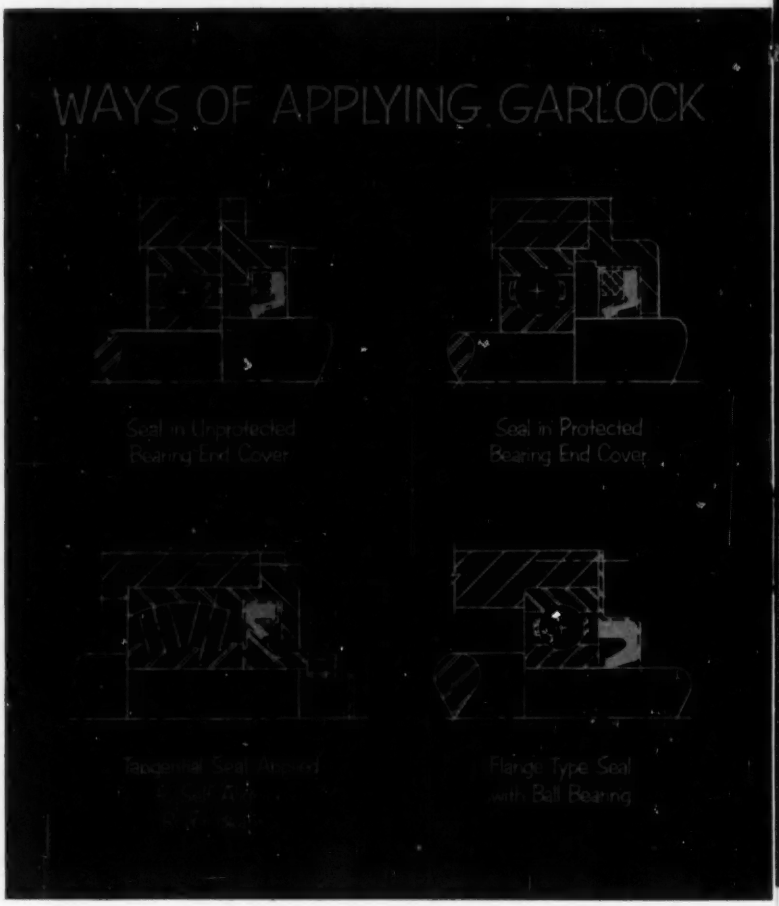
Selecting a Seal

Any ball or roller bearing seal must do two things: (1) It must keep lubricants in; and (2) It must keep dirt and grit out.

Factors to consider when selecting a seal are whether the shaft operates at high or low speed, whether the bearing load is heavy or light and whether the operating temperatures are high or normal. Also remember that the sealing of oil requires a more efficient seal than the retention of grease.

Seal Types

There are, of course, many kinds of seals used to protect bearings to some degree. Unit or lip type seals, such as the Garlock Klozure* Oil Seals illustrated, provide the best protection for automobiles, tractors and industrial machinery.


WAYS OF APPLYING GARLOCK
Seal in Unprotected Bearing End Cover
Seal in Protected Bearing End Cover
Flange Type Seal with Ball Bearing

A

shows a Garlock Springless Klozure Oil Seal used where heavy lubricants are to be contained and dirt excluded.

B

shows a Klozure with finger spring, very efficient for normal and high speed oil sealing on all size shafts.

C

shows a lip type Klozure with garter spring for sealing oil at normal and high speeds on shafts from 1" to 10".

D

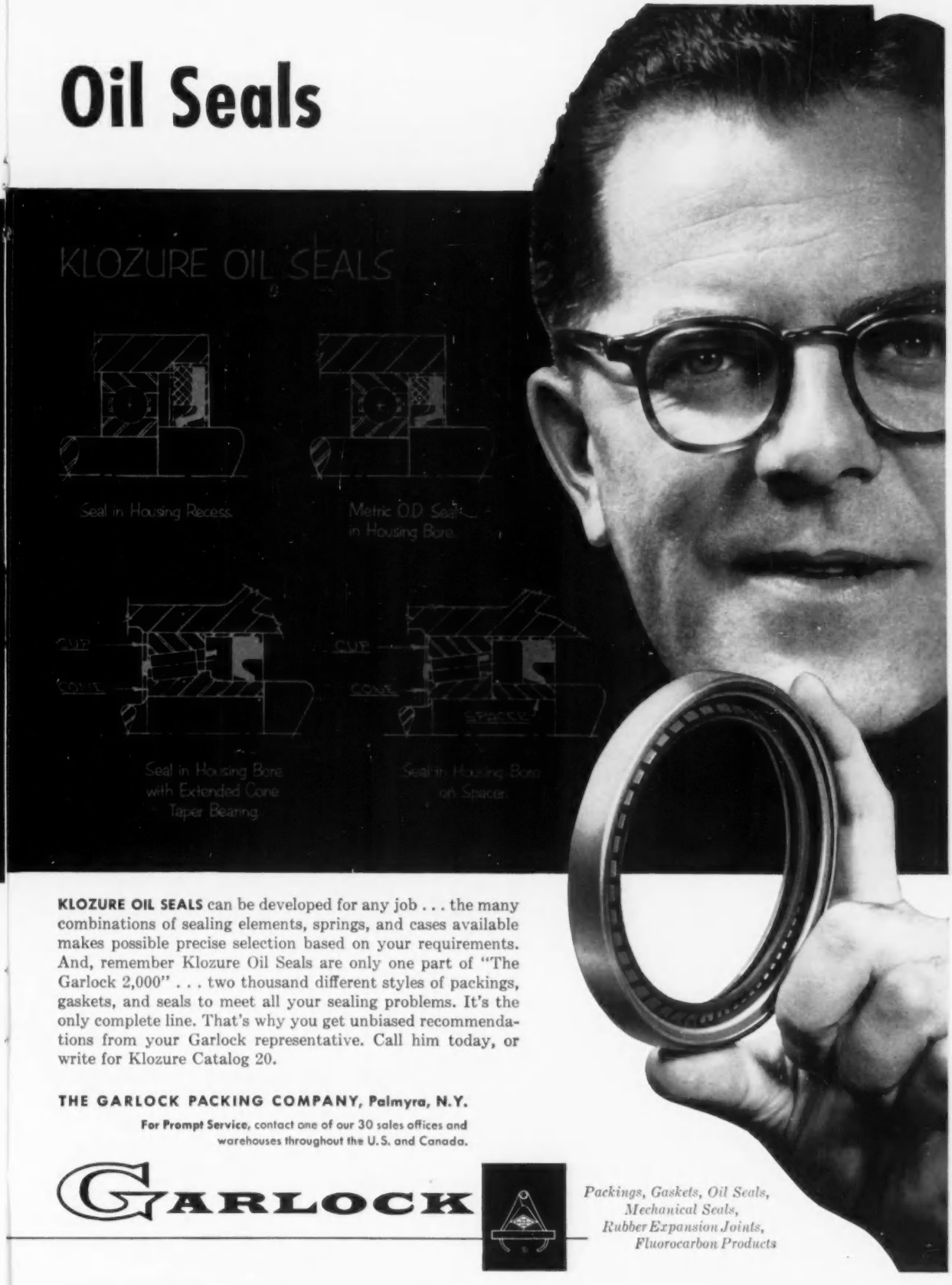
shows a Klozure oil seal with combination finger and garter spring for use on large shafts operating under severe conditions.

E **F**

Klozure Oil Seals are also available in dual tandem (E) or dual opposed (F) constructions for unusual sealing problems caused by operational or environmental conditions.

*Registered Trademark

Oil Seals



KLOZURE OIL SEALS can be developed for any job . . . the many combinations of sealing elements, springs, and cases available makes possible precise selection based on your requirements. And, remember Klozure Oil Seals are only one part of "The Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals to meet all your sealing problems. It's the only complete line. That's why you get unbiased recommendations from your Garlock representative. Call him today, or write for Klozure Catalog 20.

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.

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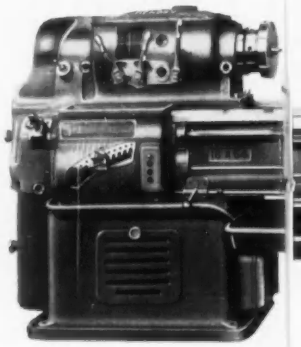
MACHINE TOOLS



Must the manufacturers of machine tools consider how appearance affects sales? Or can their customers' long-standing insistence that only performance, efficiency and ease of maintenance be taken at face value? *Product Engineering* asked some of America's major builders of production equipment this double-barreled question and their replies constitute one long comment on the difficulties of satisfying a demand for good looks made by customers who won't admit ever considering such a factor.

One manufacturer has concluded that machine tool users unconsciously associate good workmanship with good looks. This contributor says his proof is the advertising these people respond to in their technical magazines, and the exhibits that stop them when touring shows. Apparently production-minded men know, although they may not realize it, that tools with a look of good workmanship improve the appearance of the plant in which they are installed, and probably also help build operator morale.

At the very least, as more than one machine tool builder pointed out, once appearance has arrested a prospect's attention he is available for the sales story, including mechanical design and operating details! And a good many machine tool salesmen include good looks in their sales talks.

But this brings problems, as one letter stated, because ". . . our engineers seem to be continually setting up barriers to prevent our machines looking beautiful." Was one engineer who replied justified in claiming that ". . . the artist (Ed—he probably means industrial designer) does not take into consideration the cost of the pattern and the operation of the machine"? And again, ". . . parts designed by artists cannot be machined."

Analysis of the replies received indicates that perhaps the contradiction does not really lie between the problem of achieving the best possible appearance and that of providing maximum performance. Study of the changes which time and experience has wrought (see illustrations) demonstrate that simplifying contours to ease cleaning and increase safety, grouping controls and indicators together to improve efficiency and operator accuracy, have always been characterized as engineering problems, solved until very recently almost entirely by engineers. Yet such activities have invariably improved appearance. Actually, the conflict arises from the need to make all vital machine parts and systems readily accessible, and every engineer and designer worthy of his salt will tackle this reformulated contradiction eagerly.

This accessibility problem has received prolonged and inspired attention in the aircraft industry, where quickly removable access panels and fasteners have sometimes proved to be the difference between life and death. Perhaps there are ideas there for machine tool builders.

The outlook for cooperation between machine tool engineer and industrial designer is not as bleak as it might appear. The following comments, typical of those received, would seem to indicate that fruitful cooperation requires only adroit guidance by management.

Engineer: "Pleasing functional exterior design is the result of efficient basic design of the machine, coupled with the safest and most efficient casing possible."

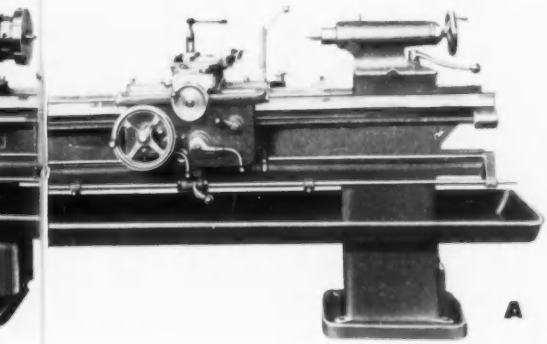
Designer: "For the men who buy or operate our machine to be satisfied and proud of their choice, the machine must be tops in performing the work it was designed for, and it must also meet these men's aesthetic needs during their working hours."

Certainly getting these two types of specialists to cooperate effectively would present no greater difficulties than these: "In our haste to get material ready for advertisements announcing our new machine, a pencil drawing was done from the plan views, prior to the machine being finished. It looked like a bunch of cardboard boxes piled up. Sales was so disturbed that an air-brush artist was hired and the exterior appearance was smoothed out with more pleasing lines. Engineering then had to revamp the guts of the machine to fit our picture."

A better way was described in another reply, from a company which employs a graduate, professional industrial designer as a full-time member of its engineering staff. "Before we put a machine on the market, many scale and full-size models are made. The men in various phases of engineering, such as mechanical, electrical, hydraulic, foundry, production, tooling and others—along with sales and advertising managers—meet and give the design a 'going over'. "Not until the models meet all requirements does work resume. The engineer and industrial designer working together must find in the machine a form that originates from inner necessity, that will be a true expression of the machine's nature."

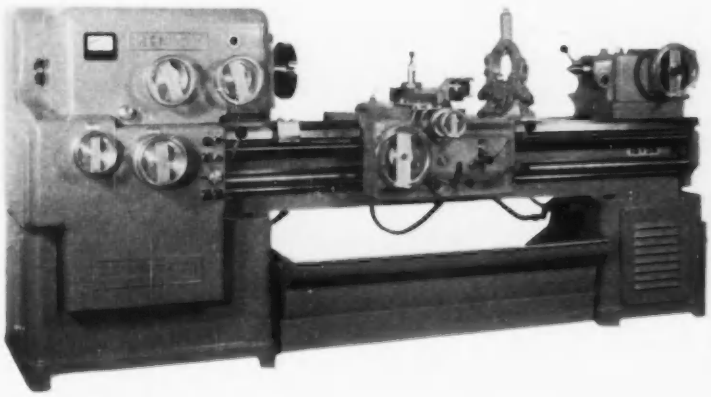
Majority of the machine tool builders replying indicated they foresaw need for major, fundamental redesign of their products in the relatively near future, primarily because of such fundamental changes in their field as the growth of automatic control systems. The fact that at least one-third of those replying mentioned that they are already employing full or part-time industrial designers indicates at least a first step towards integration of form and function. J.K.

design...

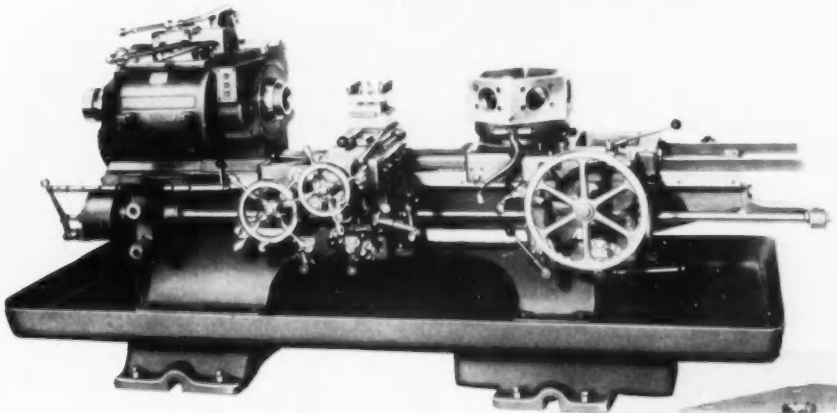


A

Increasing versatility and changing the means of controlling a machine tool are among the factors behind their evolution, as demonstrated here by old 18-speed (A) and newer, redesigned 32-speed (B) Hendey lathes, made by Barber-Colman Co.



B



C

Two stages in the same evolutionary procedure are illustrated by Warner & Swasey turret lathes (C, D). Changing to hydraulic actuation and control and necessity of grouping all units of this system together dictated single, large rectangular housing on newest all-hydraulic headstock model.

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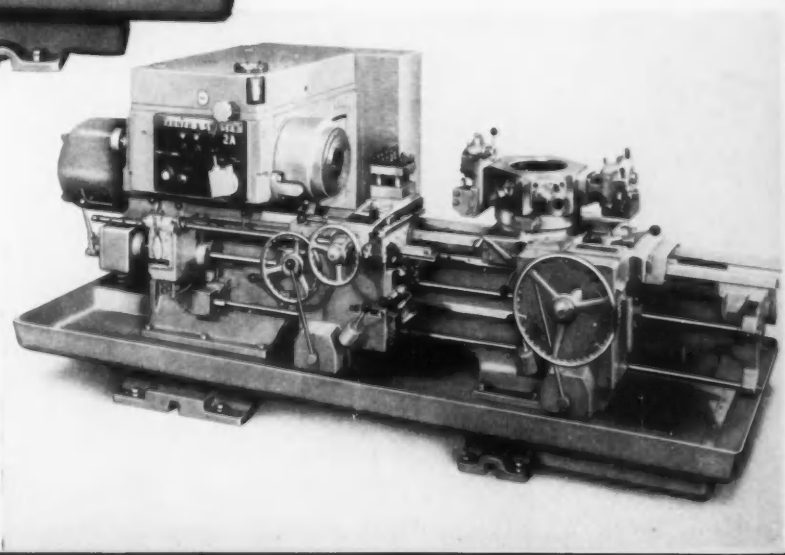
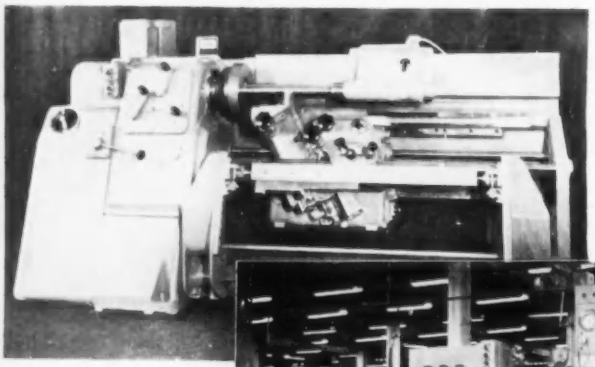


D

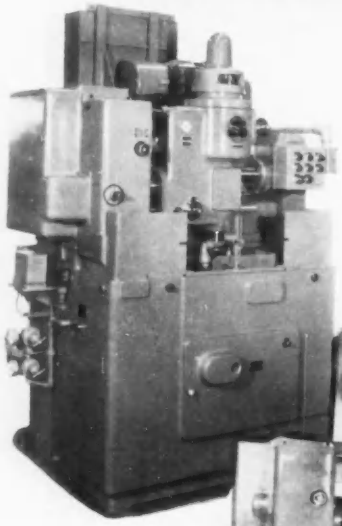
TRENDS in appearance design...



A

B

Where and how to add automatic control components and systems to existing designs while retaining an integrated appearance is difficult without major redesign. An example of one of the more successful attempts is the New Britain Machine Co.'s copying lathe, shown as first redesigned from the original Swiss machine for the American market (A), and in one of the current versions (B), with fully automatic loading and unloading devices added. Pyramidal shape lends rigidity and strength. Standard gear cutter (C) made by Fellows Gear Shaper Co. can be adapted to any degree of automatic operation by adding components and accessories, as indicated by the fully automatic unit (D). Automatic control equipment and control are encased and mounted atop Bryant Chucking Grinder Co.'s internal grinder (E).



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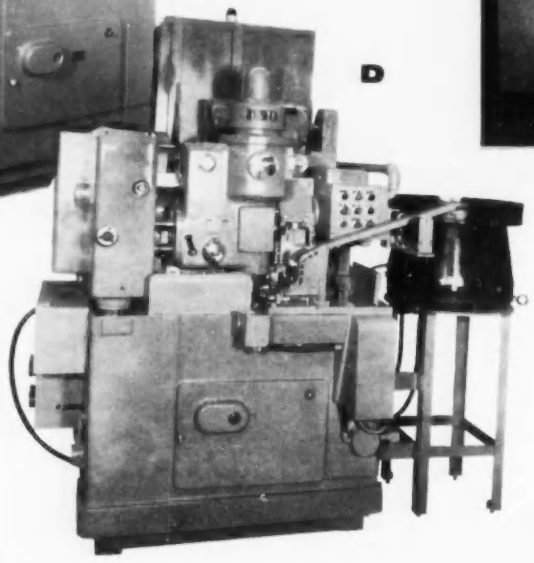
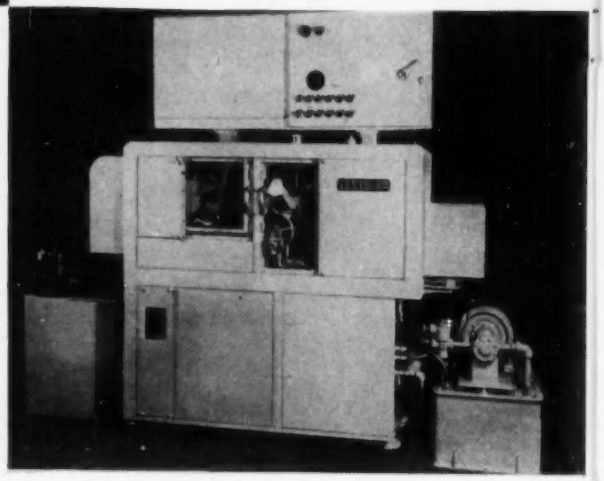


D

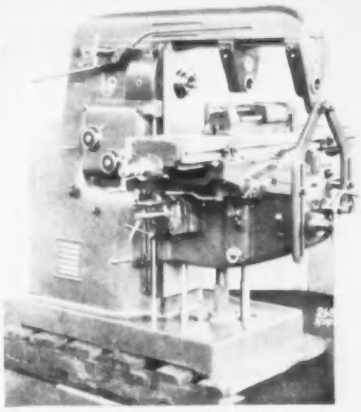


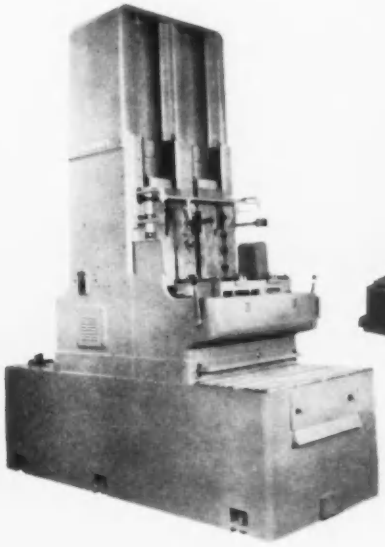
E

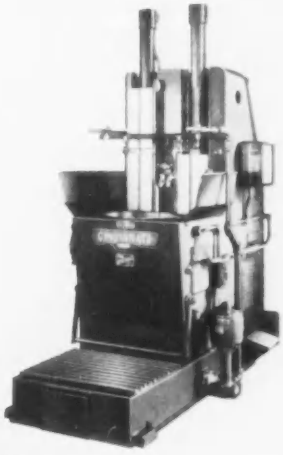
MACHINE TOOLS

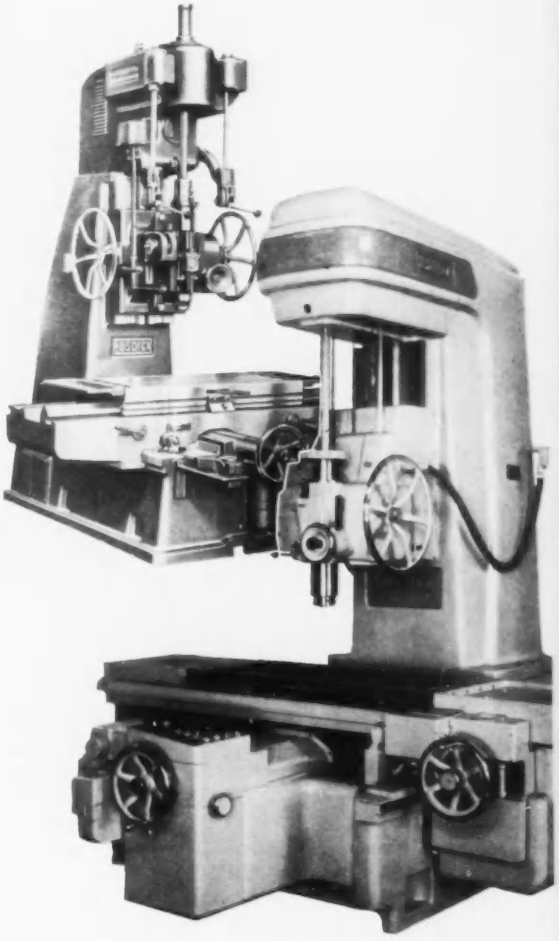
contd.

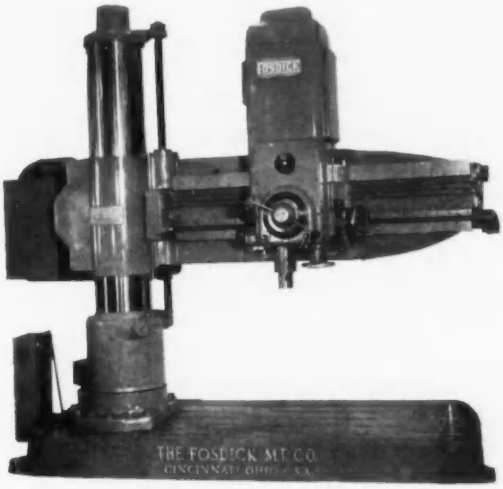
"Before and after" views of equipment by two manufacturers who, like Warner & Swasey, reported that they now use the services of professional industrial design talent. From top, Cincinnati Milling Machine Co. plain dial-type milling unit, knee-and column (independent overhead spindle) model, vertical hydraulic broaching machine. Bottom, Fosdick Machine Tool Co. jig borers and radial drills.











LEARNING CURVES

— Key to better labor estimates

Out of children's classrooms came this simple mathematical tool that accurately tells what labor costs to expect.

MORTON S. TITLEMAN, P. Eng.
Dominion Bridge Co., Ltd. Montreal, Canada

Too high a quotation means lost business; figure your bid too low, and you lose money. Estimators must hit the profitable in-between range to stay in the race with keen competition. This is where the "learning curve" can go to work for you.

It originated in classrooms over 30 years ago. Psychologists were studying the rate at which students learned school tasks. Curves showed that, as a student became more familiar with his task, he took progressively less time to perform it. Research since then shows the same is true of industrial workers on jobs involving skill.

Direct labor usually accounts for almost all routine engineering and drafting costs, and a large part of production costs. This is a situation tailor-made for learning curves.

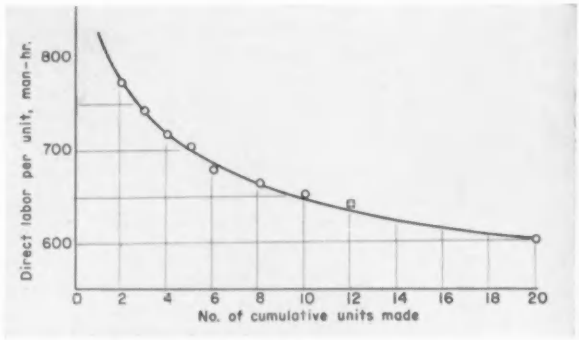
How important such analysis can be is pointed up by the experience of a custom plant that made five large welded engine blocks. Cost accounting later showed it took 3750 man-hr of direct labor to do the job—an average of 750 man-hr per unit.

Some time later a second contract, for 20 blocks, took 13,265 man-hr—an average now of 663 man-hr per unit. Fortunately, this contract was carefully time-studied. Though the first unit took 820 man-hr (Fig. 1), the eighth was completed in 660 man-hr and so on until the last took only 600 man-hr.

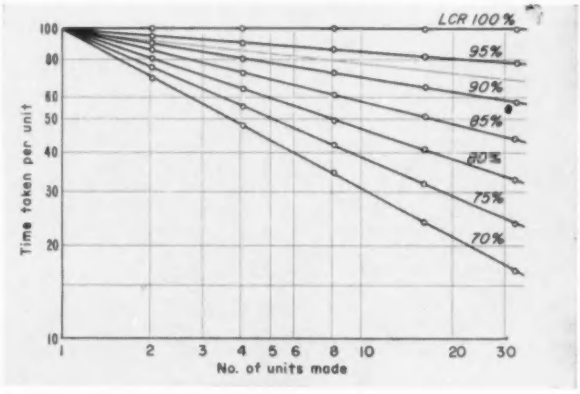
If the second lot of 20 blocks had been out for bid, estimators might have used the previous cost return of 750 man-hr per block as a basis for quotation, perhaps with an added 10% for contingencies. Such a quotation would have been about 20% too high—more than enough to disqualify it.

This is analysis by hindsight, but it's on the right track. Fig. 1 reveals that labor times for doubled quantities decreased at a constant ratio. The first unit took 820 man-hr; the second, 770 man-hr; the fourth, 715 man-hr; and so on. The ratio of these successive doubled quantities is 0.93—and this curve is called a 93% learning curve.

To simplify their construction, such curves are usually plotted on log-log coordinates. This makes them a straight line plot, as shown in Fig. 2. Such curves eliminate guesswork in advance, the guesswork that usually tempts executives, under intense pressure, to overbid rather than risk a loss—because they have



1. Engine-block fabrication . . .
has a remarkably consistent relationship between labor per unit and number of units made.



2. Learning-curve ratios . . .
range between 70% and 100% in industrial applications. They are here plotted in log-log co-ordinates. The 93% curve (in color) applies to the engine blocks in Fig. 1.

armed themselves with charts and analytical ratios, and try to play safe with "contingency factors." These often turn out to be disqualifying factors.

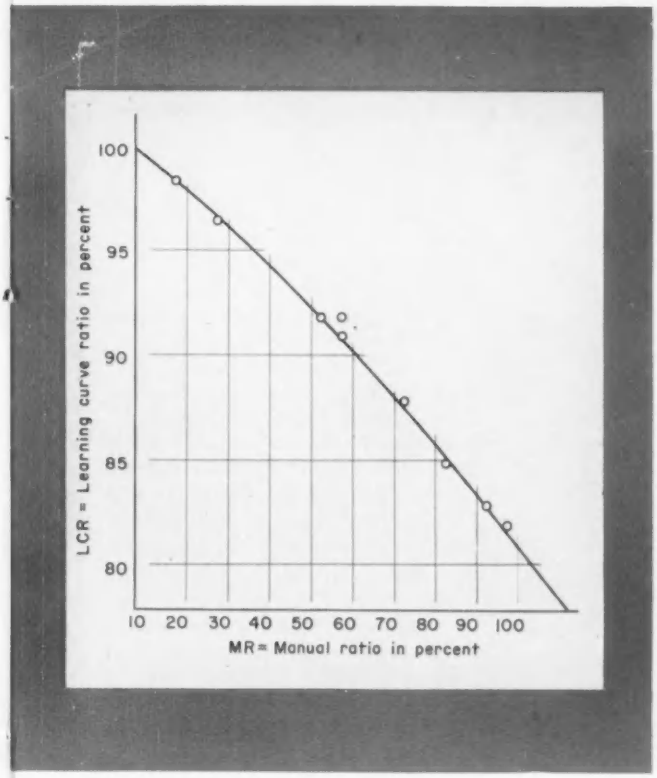
Learning curves give strength at two weak points:

Labor-cost data derived only from accounting methods reflect past performance. Though they may be historically accurate, they're usually inflexible and static.

A good quotation estimate is a prediction. It should be based on accurate data flexibly arranged to permit projection to the time of required performance.

MECHANICAL AND LEARNED OPERATIONS

Most manufacturing operations combine manual and mechanical elements—the exact proportion depending on the operation. Familiarity can reduce



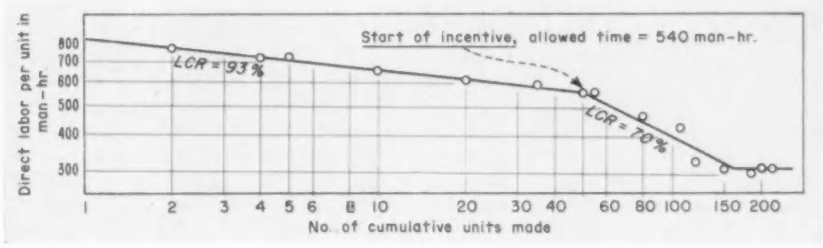
3. Correlation of LCR and MR . . .
is plotted from the numbers listed in Table I. For any measured Manual Ratio, the Learning-Curve Ratio may be read off with max error of 2½%.

TABLE I—Learning Curve vs Manual Ratios

Operation	Ratio of Elements, %		Learning-curve Ratio, %
	Manual	Mechanical	
Gas cutting, thin plates—machine	75	25	85
Gas cutting, thick plates—machine	50	50	92
Shearing plates	90	10	82
Grinding—manual	10	90	98½
Chipping—pneumatic	10	90	98½
Blast cleaning	10	90	98½
Milling—no jig	20	80	96½
Milling—with jig	10	90	98½
Assembly—no jig	85	15	98½
Assembly—with jig	50	50	92
Fitting	85	15	83
Welding—manual	65	35	88
Welding—submerged arc	35	65	94

TABLE II—Manual Ratio of a Combined Operation, %

Operation	Manual ratio	Proportion of total Operation	Weighted Manual Ratio
Shearing plates	90	4.0	3.6
Gas cutting—machine	50	6.0	3.0
Gas cutting—manual	75	8.0	6.0
Assembly with jig	50	23.0	11.5
Milling—no jig	20	4.5	0.9
Chipping (air chisel)	10	3.0	0.3
Grinding—manual	10	7.0	0.7
Welding—manual	65	11.0	7.15
Welding—s. a	35	28.5	10.0
San blasting	10	5.0	0.5
	Total Effective Manual Ratio =		43.65



4. Incentive program
in this history of 200 consecutive engine blocks, was started after 50 were completed, and lowered the LCR to 70%. After 160 units, curve levelled off to a constant production time.

labor-time on a manual task but not on an automatic operation (100% mechanical). The proportion of manual elements in an operation should, therefore, affect the degree of "learning" or labor reduction. Different operations have different learning-curve ratios, depending on the proportion of manual elements.

To obtain data that would correlate the learning-curve ratio (LCR) for specific manual ratios (MR), operations in several industries were observed over a period of years. A partial list of typical operations in a large steel fabricating plant are shown in Table I. and plotted in Fig. 3.

Any operation for which the proportion of manual work elements (MR) is known has an indicated learning-curve ratio with less than 2½% error. Analysis of a single cycle of an operation is usually sufficient to determine the proportion of manual elements. With the correlation curve, therefore, a single observation is sufficient to indicate the probable trend of the operation for preceding as well as subsequent units.

When determining the MR for individual operations, some variation may be noted at different times or on different products. Even the same operation on the same product will often show small variations, because the manual work elements are being reduced as learning takes place. These variations are usually in the range of 5%, so the average of several independent observations will usually give an excellent MR value for the purpose.

Observation or time study of a particular operation may not always be convenient or possible at the time its MR is desired—when an operation is not being performed at the moment, or when a new product will introduce the operation to the plant for the first time.

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1 H.P. 115 Volts A.C.
20 Amps—250 Volts A.C.

Two types available: Double Action Type actuates switch contacts when actuator is moved either side of "at rest" position. Single Action Type operates from one side of "at rest" position only. Both are designed for long life under heavy use.

AVAILABLE TYPES

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242-0011-03	Four circuits (two open, two closed)	8	Single
242-0010-03	Double circuit (one closed, one open)	4	Double
242-0012-03	Double circuit (one closed, one open)	4	Single
242-0019-03	Double circuit (normally closed)	4	Double
242-0017-03	Double circuit (normally closed)	4	Single
242-0020-03	Double circuit (normally open)	4	Double
242-0018-03	Double circuit (normally open)	4	Single

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LEARNING CURVES
(continued)

Under such circumstances a useful MR figure can be obtained by reference to previous time-study records of similar operations. It is even possible to set up a synthetic time study by listing all necessary work elements with their appropriate time values. Reasonably accurate MR and LCR ratios can then be obtained.

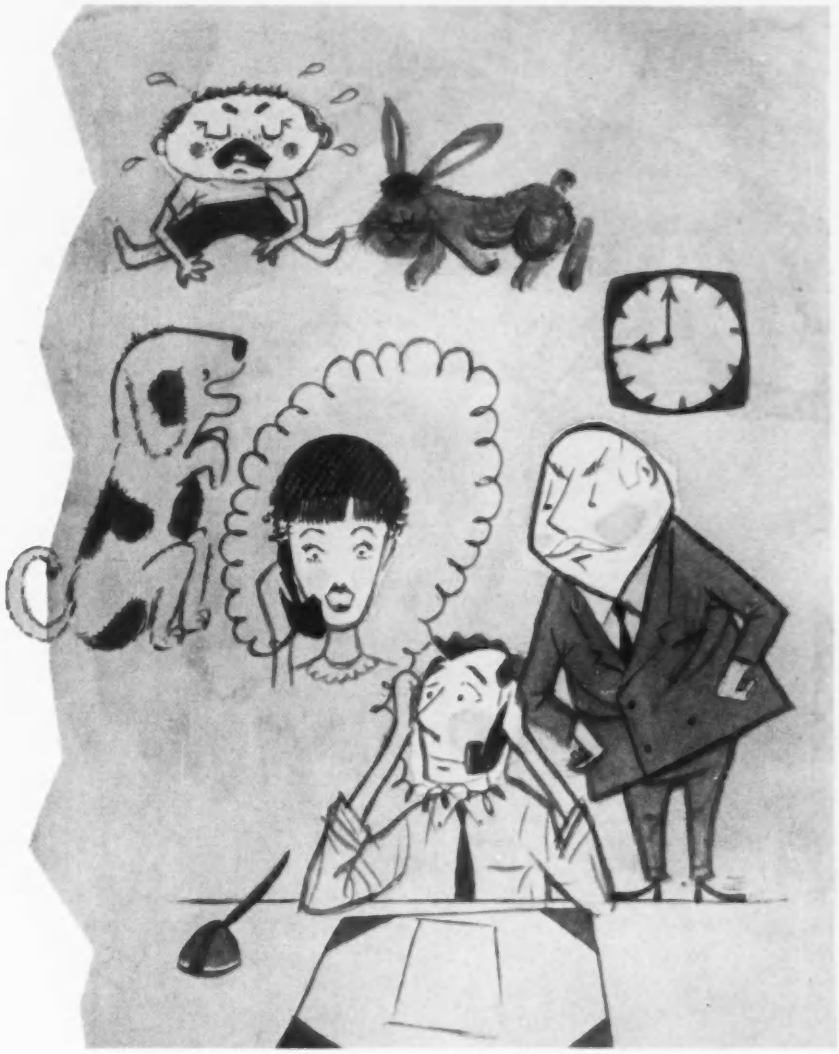
The correlation curve applies equally well to the combined operations of a complete product. But the total effective manual ratio for all operations must be known. To obtain this MR, first list each individual operation and determine the proportion that each occupies in the total elapsed time. Then multiply the MR for each operation by its proportion of the total time. This gives a weighted manual ratio for each operation. The total of these ratios is the effective MR and can now be applied to the correlation curve to determine the effective LCR. Table II is an example of this procedure for the engine block.

From the correlation curve it is found that for an effective MR of 43.65% the effective LCR = 92.2%. Note that this compares remarkably well with the actual observed learning-curve ratio of 93%.

As a result of the low cost of fabricating the engine blocks, a series of additional contracts were awarded and completed without interruption. Careful observations, graphed in Fig. 4, show the labor history of 220 completed blocks. Labor reduction was constant and followed the anticipated trend of 93% learning curve until the 50th unit was completed. At this point the job was put on an incentive plan with an "allowed" standard established at 540 man-hr. The plan reduced the learning-curve ratio to 70%. The reduction continued until a minimum plateau of 300 man-hr was reached. No further reduction was then apparent even though 50 more units were made.

OTHER USES

Learning curves will work for a wide variety of applications. A few of the more important are: training of engineers and draftsmen, machine and plant loading, delivery schedules, manpower forecasting, overhead burden, "make" or "buy" decisions, pricing policy, personnel training. Ω



SIDNEY REITMAN

To keep peace
in the family

And your boss
off your neck

It ain't what
you say . . .

It's how you say it

A three-act fantasy that points a very practical MORAL.

It was one of these modern plants standing well back from the highway —a wide green lawn, a white-stone structure with long-paned windows. Inside, in a crowded cubicle (but one he could call his own), Howard Wilson puttered happily.

His test on the EX-1 Core Memory was going well. It had a lot of bugs still—but with a bit more work—why, there was no telling what a space saver this new gadget would be!

ACT I

The desk phone burred dully. He picked it up, saying "Wilson here." He'd heard that last night in a British movie.

"Well, I'm glad you are." It was P. G. Dirkson, director of research. "It looks like bad news. The heat's on EX-1. The front office wants a report—a finding. They want something to show for two million dollars in research and development. They've made themselves quite plain about it."

Wilson was silent for a moment, shaking his head. "But look, P. G., how can we? I admit we've got some of the facts, but the whole story isn't in. It won't be for at least a month. I've got more work to do on the breadboard. What can we say today —that we're six laps in and six more to go?" He'd picked that one up from reading *Turf*.

"Look, Wilson. Don't start talking like a parimutual machine. We're not running a horse race. They want a report—now. It's as simple as that. Got it?" And he was gone.

The phone burred again. This time it was his wife, Cathy. "Oh, Honey, what a morning! That dratted washing machine busted a pipe or something, and it took me an hour to clean up the flood. And right after that, Champ came into the house,

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dragging a dead rabbit. Ugh! It was awful! Can't you teach that bloodhound anything? Then Richie saw the rabbit and he started to scream his head off. He's still at it. Because of Richie screaming like that the dog began to bark—and between the two of them, well listen . . ." he could hear, faintly, cries and yapping wails. "So what am I gonna do?" Cathy finished weakly.

"I'll tell you what," he said calmly. "First smoke a cigaret. Then give Richie a graham cracker. Pick up the rabbit with a shovel and bury it in the yard. Then go over to Champ and give him a good wallop with the back end of the shovel. Okay? Keep your chin up. What are we having for dinner?"

"Umm, your favorite. Peppers and eggs. Bye, dear."

He went to the lab bench and silently surveyed the apparatus that stood on it. Poised on a shelf, behind a clear-plastic front, stood EX-1, a core memory one-twentieth the size of its nearest counterpart in the digital field and almost 10 times as efficient. From its amber-colored field, a maze of wires led down to a battery of scopes and meters. If this works, he thought, we could take all the knowledge in the average-size public library, code it, and store it in one small room —if this works.

But how can I be certain till I've completed my tests? I must think about it as a "probable" device . . . strictly in terms of the uncertainties. How do you write about an uncertainty and still make it sound worthwhile? He simply didn't know. He'd never before written a report with this as its theme. He sat down at his desk and pulled out a pencil and pad.

ACT II

"Now let me see—what would be the best way to begin . . .?" The subject lent itself so beautifully to phrases like binary quadrants, arithmetic mean continuum, crystalline junctions, cellular triggers . . . but what would they mean to men who had never lived with them as he had? They had no concept of the beautiful simplicity of the finished units, and they were certainly incapable of understanding the complex theory.

He became conscious of a tremendous weight on his shoulders. Where to begin? Where to begin? If only the core memory had, in fact, already succeeded, he could at least tell of its success. But now he couldn't even do that. What then could he write? Finally he began:

In the continuous development of core-memory storage, some significant developments have been observed in allied experimental fields such as binary logic and triggering circuits with cores consisting of crystalline junctions. To these fields, however, new empirical data has been introduced; and among the more significant ideas are the theory of "junction" to pure Boolian postulations and the as-yet-unconfirmed theory that a disulphate crystal which exhibits unusual properties at high temperatures can be substituted for the conventional LCR circuit.

He put the pencil down and looked at the words once more. He got up, thinking—oh, that's for the birds—and went out into the corridor. He strode toward the canteen, thoroughly disgusted with himself and with what he had written. It was a labyrinth of words, meaning nothing.

Ernie Wood was at the canteen in engrossed conversation with a stranger. Ernie was a whiz on crystalline structures.

Ernie pushed a finger toward the stranger: "Howard, I'd like you to meet Alfred Tompkins. Howard's deep in a study of core memory."

"That's a big job, I guess. I don't envy you." Tompkins said it in an easy-going Midwestern drawl. "It's all quite new, isn't it?"

"Yes," Howard nodded. "Newer than a baby. It hasn't been born yet." As he spoke he noticed the lines on Tompkins' face, the silver hair, then the eyes, warm and brilliantly alive. He suddenly realized he was in the company of an old and, quite probably, erudite man. "I'm surprised—surprised you know anything about core memories, I mean."

A humorous twinkle crept into the old man's eyes. "I'm a professor at Midwestern University," he said. "I keep in touch, but it isn't easy—considering the fog a person has to sail through these days."

"Fog? How do you mean?"

"Well, the fog of words in reports. I think you will admit they aren't written at all clearly?"

Howard smiled ruefully. "O, I'll admit that, all right. But how in the world do you get out of the fog? I'm right in the middle of one now. I'm trying to write an interim report on our core memory, the EX-1. Frankly, I just don't know where to begin. Sure my language is foggy! But knowing that doesn't solve the problem."

"In part it does," the old man said.

"I guess I know what you mean," Howard said. "Knowing you're wrong is half the battle. But I'd like to write it pretty much as I'd tell it to a friend."

"Why don't you?" said the old man quietly.

"And the past, the accepted pattern, the conventions—?"

"But you know as well as I do that writing—language—it's a living, a changing thing. There's nothing static in thought."

"Write as you think—h-m-m," Howard murmured, almost to himself.

"Of course," the old man said. Then he raised his hand in farewell. "Well, gentlemen. I've had a pleasant morning, but I must be off—the Ivy Tower calls." They shook hands and he turned away. There was a momentary silence.

"Ernie—just who is Tompkins?" Howard finally asked.

"He's supposed to be a wheel or something down at the University. He teaches philosophy. I believe he's got a chair in it. What do you think of him?"

"He's right. He's so right."

ACT III

Howard got back into his cubicle just in time to hear the last burr of the phone.

"P. G. here, Howard—have you begun the report?"

"I made a start, but I don't like it."

"How does it sound?"

Howard obligingly read the paragraph through—and waited.

After a moment, P. G. said, "Wow!", rather subdued. "What does it all mean?"

Howard laughed outright. "Who knows? But it sure sounds learned, doesn't it?"

"Yeah—it's likely to scare a rabbit out of his fur."

"Well, I'm making a fresh start. I'll probably finish it by tomorrow afternoon."

"Great stuff, Howard. Call me the first thing, will you?"

He picked up the pencil and he began to write:

It is true that we've spent much time and money on the EX-1 core memory, and with very little to show for it, to date. But this memory, when it succeeds in its purpose (and there's every likelihood that it will) shall pay us back 10-fold and more for our investment. In fact, its potential use in the computer field is unlimited. But there is still a good deal of design and test that needs to be done. This much is certain: We have within our grasp a new kind of core memory that can store in a few cubic feet as much information as is present in 10,000 books. We can easily recover this data by connecting the memory to a simple, electronic switching circuit. No such device, having so tremendous a capacity for work, exists today in the computer industry . . .

The idea originated three years years ago. At that time, Enrique Martino (of the Computer Laboratory) found that a labyrinth of disulfate crystals, looking much like a jungle of spider nests, would hold 10 times the data we could put into the conventional core. Furthermore, it was one-twentieth as big . . .

He paused, well under way, feeling he had found the words to lead him out of the mental labyrinth.

The phone burred again. It was Cathy. "I'm calling to say that Richie stopped crying, the dog stopped barking, and the garbage people took the rabbit away. Isn't that wonderful?"

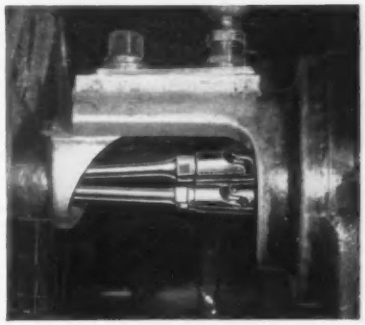
"Like we said, honey," he put in, "peppers and eggs?"

"You sound much better. 'Bye dear."

He strolled over to look at the EX-1 core memory. He touched one of the wires that fell from the maze.

"Thanks Tompkins," he said. Ω

Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

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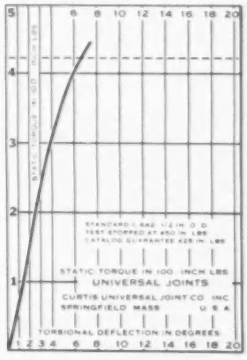
Torque Curve ½" Curtis Universal Joint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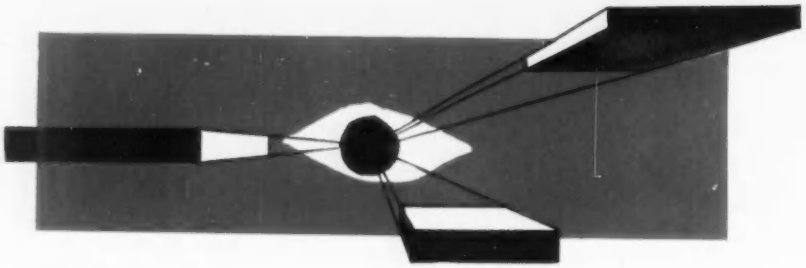

POINTS

THE QUESTION:

Have simplified drafting procedures saved you money?

"No two brochures or books . . .

on simplified drafting are alike or agree on techniques of delineating a drawing. Compare these with drafting standards published by the ASA, those of the SAE or military standards. The reader will find numerous practices on which all concerned agree.

"Practically all draftsmen received their early training from schools which taught from textbooks using the principles of drafting based on ASA standards; hence, it is reasonable to assume that all draftsmen are familiar with a method of delineation which is commonly understood. To teach people a system of simplification by omission costs money; add to this the cost of training those who must read and interpret the 'shorthand' and it becomes extremely doubtful if the time saved in actual delineation of a drawing will reflect itself in the final cost of the product. Any form of teaching or training is expensive. Ask the taxpayer."

J. GERARDI
Asst. Dean, College of Engineering
University of Detroit
Member ASA Y-14 Executive Committee and Steering Committee,
Automotive Drafting Standards, SAE

ARTHUR H. RAU
Consultant Drafting & Engineering Service Div.
General Electric Co.

"Definitely yes. . . .

For a period of almost a quarter century prior to 1946, sporadic efforts to save drafting time and improve efficiency by simplifying outmoded drafting practices were made in the General Electric Co. Under the growing pressure of the pronounced shortage of skilled technical personnel, a more consistent and far-reaching program to save time and effort in drawing preparation and reproduction was instituted some 10 years ago.

"These practices were then explored through an extensive teaching activity which brought the new concepts and standards to the personal attention of more than 15,000 people in the Company's engineering, drafting and manufacturing operations.

"An all-inclusive statement of the monetary savings which have accrued has not been compiled but evidence in General Electric, as in many other industrial concerns, show that the time for drawing preparation can be reduced by 30 to 40% through judicial application of the new functional principles. At the same time, the amount of drawing and reproduction material required is reduced. With that reduction goes a cut in the effort of handling and using drawings."

OF VIEW

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DON FULLER
Senior Planning Assistant
Planning & Development, H. K. Ferguson Co.

ROBERT S. JONES
General Manager, Product Divisions
Jones & Lamson Machine Co.

"It certainly has. . . .

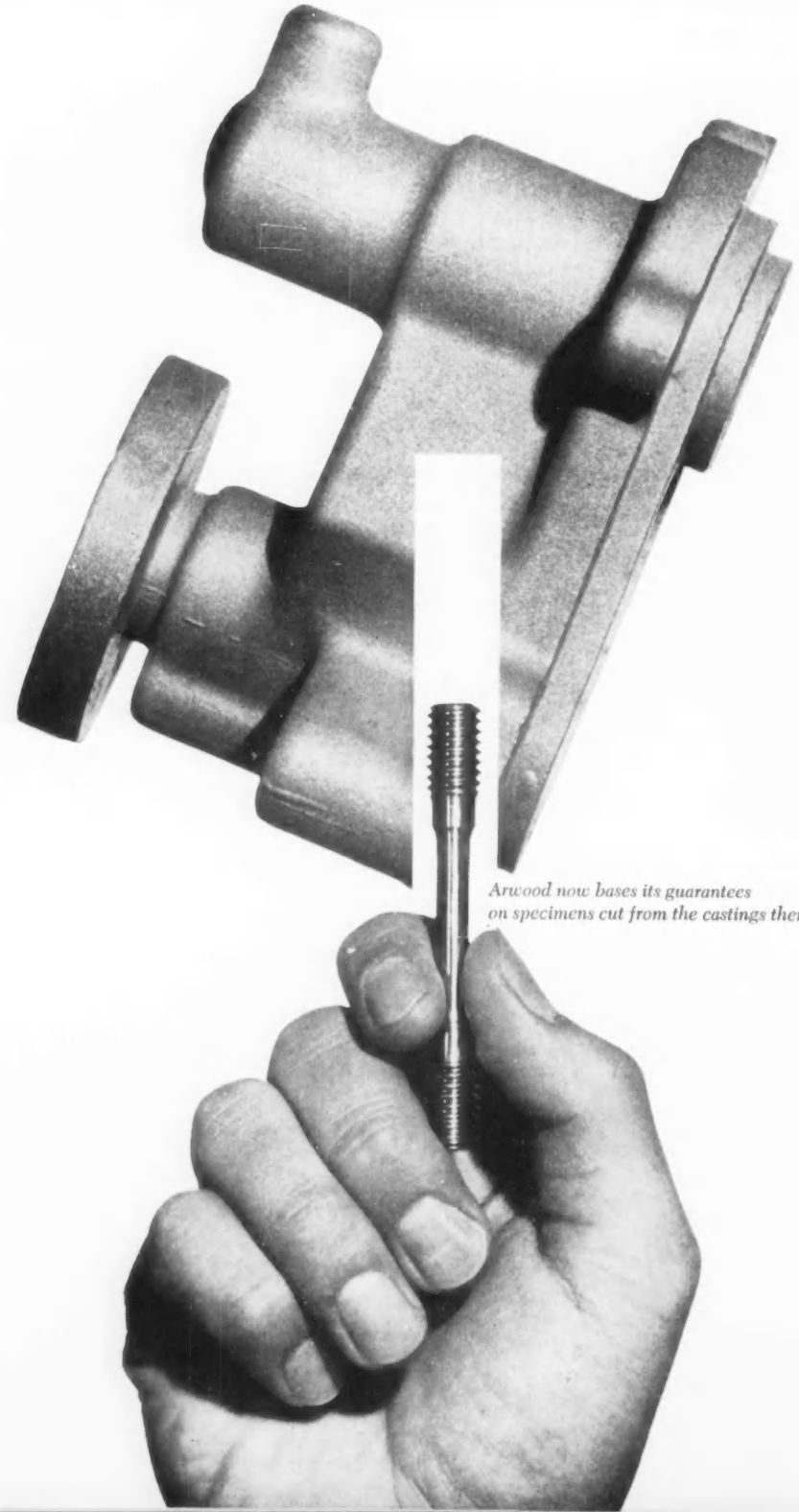
I would conservatively estimate that our over-all drafting costs have been reduced 30% where Simplified Drafting is fully utilized. Part of this saving is due to reduction in drawing size, and in blueprinting, filing and handling costs."

"The outstanding saving . . .

is reflected in time. The construction of pilot machines on which experimental and research work is done must be accomplished speedily. Design changes, modifications and improvements brought about by tests require the draftsmen to release drawings rapidly so that additional tests and modifications can be made and the machine placed in production quickly. Once a shortcoming in a design is uncovered and corrective measures are known, time spent converting these measures into the language of the producer (drawings) might be considered time wasted. Simplified drafting might then be compared to a new time-saving language."

J. H. BORNZIN
Divisional Chief Engineer
Farm Implement Division
International Harvester Co.

Now—a major advance in



Arwood now bases its guarantees on specimens cut from the castings themselves.

aluminum investment castings!

Arwood now guarantees better-than-Aircraft-Quality properties in the casting itself

Arwood's Research Staff has perfected a new technique of investment casting aluminum . . . a technique that makes it possible to guarantee mechanical properties far higher than Aircraft Quality and guarantee them in the casting itself. The new Arwood "Suparcast" process gives you 37% greater tensile strength . . . 52% greater yield strength . . . a threefold improvement in elongation . . . in all areas of the casting. In stressed areas, these minimums can be raised even higher!

And here's the real news: *These guarantees are based on specimens machined from actual castings.*

It's easy to understand how the new "Suparcast" process can help you shuck off the historical limitations of aluminum investment castings. Now at last you know exactly what properties you are getting in your castings. Now at last you can use aluminum investment castings for structural applications, even where shock and impact are involved.

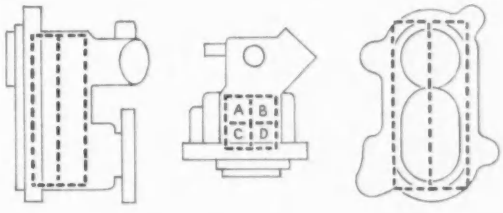
Another very practical consideration: If you are now using 356-T6 alloy investments, you can switch to castings made by Arwood's "Suparcast" process *without the need to change specifications.*

If you'd like to learn more about Arwood's new process, write, wire or 'phone for complete details.

COMPARISON OF MINIMUM MECHANICAL PROPERTIES OF 356—T6 ALUMINUM ALLOY
Suparcast Guaranteed Minimums vs. Government Aircraft Quality Minimums
(Test bars cut from castings weighing less than five pounds and with maximum sections less than 1" thick.)

	Ultimate Tensile Strength		Yield Strength		Elongation	
	psi	% increase	psi	% increase	%	% increase
AMS 4260	24,750	—	16,500	—	0.7	—
Arwood Suparcast (all areas)	34,000	37.4	25,000	51.5	3	300
Arwood Suparcast (critical areas)	38,000	53.5	27,000	63.6	5	600

HERE ARE ACTUAL MECHANICAL PROPERTIES IN VARIOUS AREAS OF THE CASTING SHOWN AT THE LEFT:



Test bar location	Ultimate (psi)	Yield (psi)	Elongation %
A	38,800	28,400	5
	37,600	28,600	4½
B	38,800	28,600	4
	37,500	27,000	5
C	41,300	29,200	9
	39,800	27,400	6
D	40,000	26,500	5
	37,400	27,600	4

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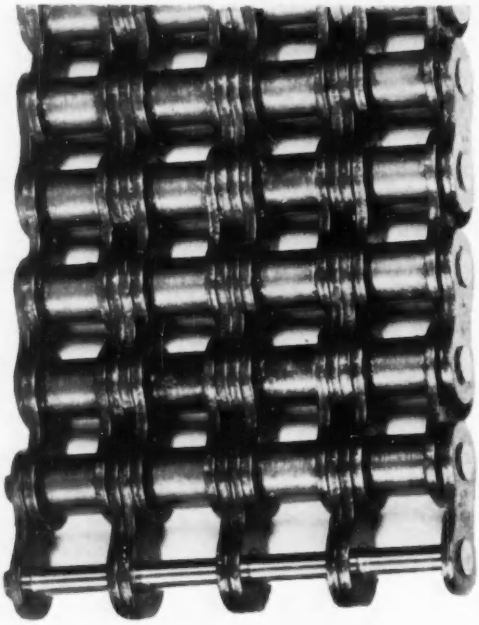
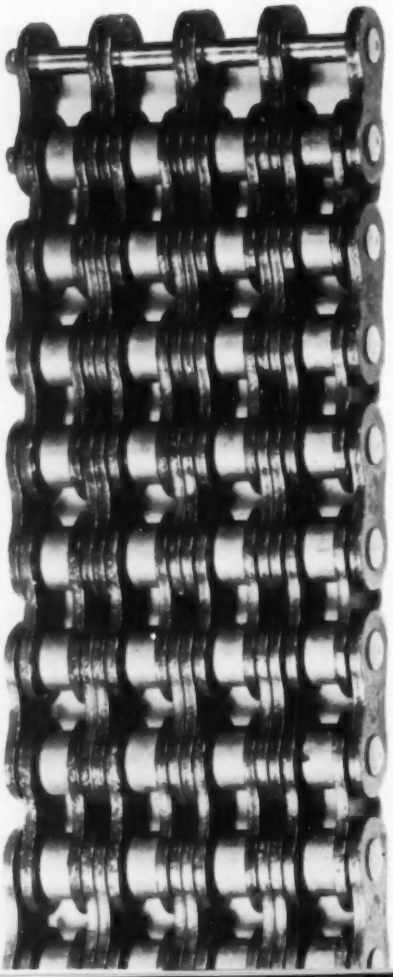
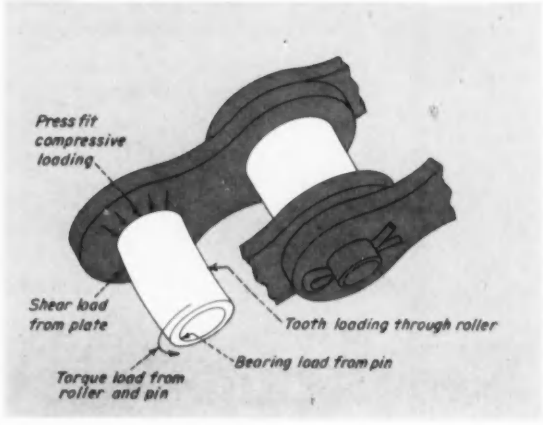


25%-narrower roller chain handles same loads . . .

because rollers are prestressed before assembly, raising endurance limit. Width of these rollers is $\frac{3}{8}$ of chain pitch instead of $\frac{5}{8}$, yet chain sprockets can still be cut with standard cutters, and tooth profile will still conform to ASA (but face width is narrower). Somewhat lessened shock-absorbing capacity of chain is offset by decreased stress on pin and bushing, a result of shorter pin length. Lessened pin deflection also means that bearing area is not reduced, because of more intimate contact throughout length of chain parts. Drawing illustrates typical loads on chain bushing. Narrower chain is now available in 1 and 1¼-in. pitch sizes. Prices: slightly above those for regular chain; delivery, 2 wk. **Whitney Chain Co., 237 Hamilton St., Hartford 2, Conn.**



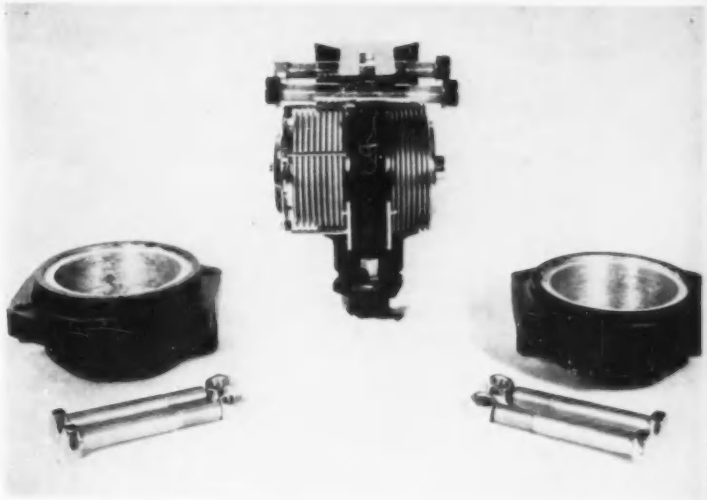

Press fit compressive loading
Shear load from plate
Tooth loading through roller
Bearing load from pin
Torque load from roller and pin

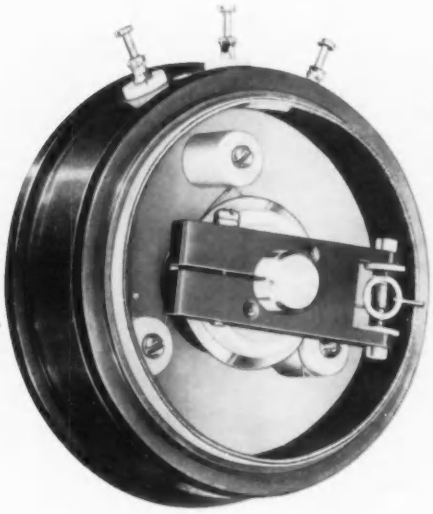
Dime-sized thermostat

MATERIALS · EQUIPMENT

Bellows-type meter measures pressure differentials . . .

and can be used with indicating or control equipment. Accuracy of ½% of scale is said to be maintained under temperature changes as great as 100 F and pressures up to 2500 psi. In operation, pressures are applied to bellows through high and low connections. As differential changes, liquid in bellows moves from one side to other, changing range-spring tension and moving connecting rod. This re-positions torque tube, and the change in differential alters transmitter output. Operating range can be adjusted in field by changing springs, available in 15 different ranges, between 0.20 and 0.400 in. of water. **Minneapolis-Honeywell Regulator Co., Minneapolis.**





Potentiometer uses dynamically balanced arm and contact . . .

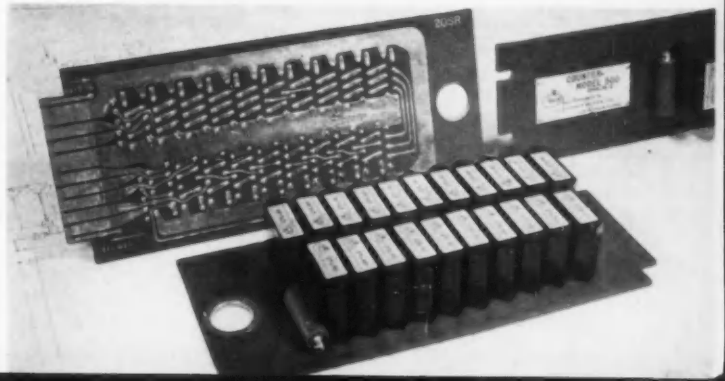
so that only light pressure is needed to keep contact assembly (mounted in jeweled pivots) in constant contact with winding, even in severe environment. Speeds of 1000 to 3425 rpm are standard, and starting torque is 0.1 in.-oz for the smallest of six available sizes (⅝, 1 ⅛, 1 ⅞, 1¾, 2, 3 in.). Mechanical rotation is 360° continuous, but stops are available. Operation to 165 C is standard, but up to 225 C is obtainable. 2-wk delivery on standard units. Priced from about $25 to $50. **Chicago Aerial Industries, Inc., 1980 Hawthorne Ave., Melrose Park, Ill.**

Transistor-equipped counters need only 1-volt . . .

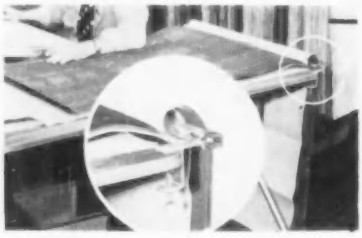
supply, and use no standby power. Based on magnetic cores and transistors, a unit with 100-million-count capacity (100,000-count rate) would use only 0.2 w average power. This unit costs approximately $435. Counters are available in a variety of housings—as small as ¼ cu in. per binary counting stage or 1 cu in. per decade. Standard decade counters are about $50 to $75. Binary counters are $16 a stage. Also, custom-designed units. **Dept. D, Mack Electronics, div. Mack Trucks, Inc., 40 Leon St., Boston 15.**

for —65 to 150 C . . .

temperature range uses a bimetal-actuated contact and is externally adjusted by a screw, as shown. Rated at ½ amp for 6 to 28 v ac or dc, 115 v ac. Weight, 0.06 lb. Delivery in about 10 days. $3.50 in small quantities; about $2.80 in production quantities. **Chatham Controls Corp., 33 River Road, Chatham, N. J.**

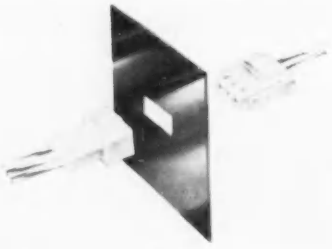


Plug-in limit switch . . .
can be replaced in seconds with any required adjustments made before installation. Unit consists of two parts, terminal block enclosure with wiring connections and switch enclosure, including all moving mechanical and electrical parts. The switch enclosure is fitted with four current-carrying spring plugs, integrally molded to the basic switching element and the terminal block with four corresponding receptacles. When plugged together, they form a complete switching unit. Meets NEMA standards for nonventilated watertight and submersible enclosures. **Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill.**



Clamps hold plans . . .
in place while the engineer leafs through sheets, even to last page. Table clamps are aluminum and attach without tools or fasteners. A twist of the wrist tightens or loosens the unit. **Plan Hold Corp., P. O. Box 1055, South Gate, Calif.**

Relays with built-in indicating lights . . .
permit instant spotting of circuit malfunctions. Available in clear and five tints for color coding. Dimensions are $1\frac{3}{8}$ x $1\frac{3}{8}$ x $2\frac{1}{8}$ in. high. Rated 5 or 10 amp, up to 3PDT, depending on placement of neon lamp. For any standard voltage, ac or dc. **Line Electric Co., 271 S. 6th St., Newark 3, N. J.**



Self-anchoring multiple connector . . .
for through-panel applications eliminates supplementary mounting devices. Contacts with the mountable and disconnect units are identical, self-cleaning and recessed for safety. The connector is polarized to eliminate circuit error. Accommodates a wide spread of panel thicknesses. One mounting hole is required. The connector permits finger-grip engagement and disengagement of mountable and disconnect units. **Amp, Inc., Harirsburg 20, Penna.**

Self-locking rubber grommet . . .
rolls back on itself to form a dustproof, moistureproof seal. Once snapped into place, it will hold a wire tightly and withstand a 35 to 50-lb pull, depending on wire covering. Accommodates any size wire. **Argosy Industries, 67 May Ct., Chagrin Falls, Ohio.**

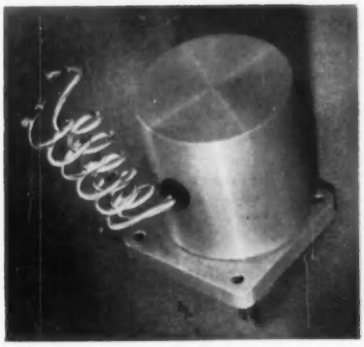
Electromagnetic angle transducer . . .
has a resolution of better than ±3 sec of arc. It has potential applications for visual and automatic angle reading systems in the machine shop and in military equipment. It has been used in an angle encoder that converts a shaft angle to a numerical representation acceptable to a digital computer. The vernier resolver is a reluctance-type, variable-coupling transformer. Two output voltages are produced in the present design, which vary in amplitude as the sine and cosine of 27 x the angle through which the rotor is turned. Thus, the equivalent of a standard resolver driven by a 27:1 gear train is obtained. Other ratios are possible. Unit is small. Windings are on the stator, leaving rotor free of sliding contacts. **Clifton Precision Products Co., Clifton Heights, Penna.**

Expansion bellows . . .
for volumetric displacement applications such as absorbing the expansion of oil in filled systems. Flexibility with low spring rates and low stress permits volumetric size reduction of 50% or more over conventional types. Illustrated is a bellows with $\frac{3}{4}$ in. OD x 0.084 solid height and a spring rate of 20 lb per in., providing a total displacement of 0.5 cu in. Sizes to 700-cu-in. displacement are available . **Belfab Corp., Agawam, Mass.**

Counter and totalizer . . .
maintains an accurate inventory check on each ingredient being fed into a proportioning system. It uses counters to record the weight of each ingredient used and totalizes the weight of the combined ingredients. Counters gage separate ingredients. Different sizes are available for recording up to 100 ingredients. Reg-

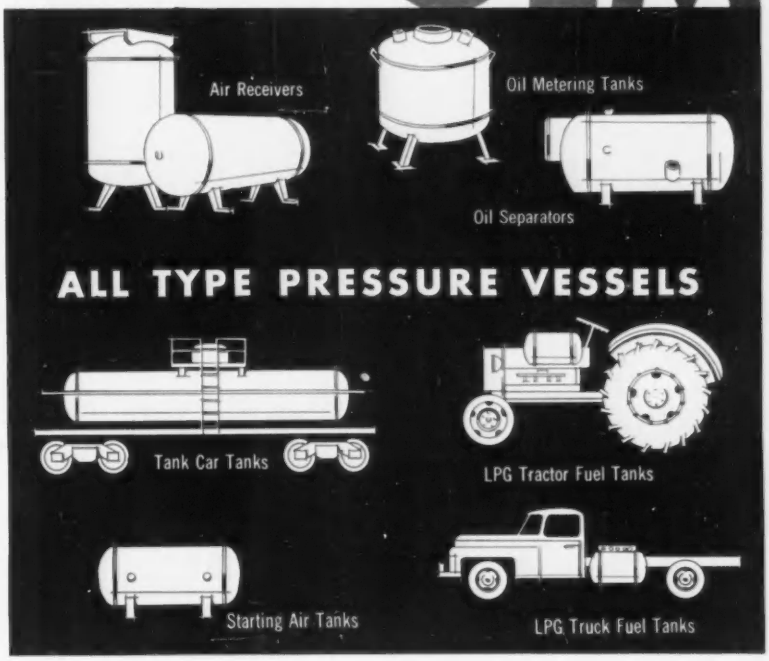
isters are of the setback type, but all are contained within the cabinet. When a bin is refilled, the counter may be reset if desired. **Richardson Scale Co., Van Houten Ave., Clifton, N. J.**

Potentiometer service kit . . . makes modification or repair in the field possible. Kit contains taps, bus bar rings and necessary tooling for on-the-spot drilling. With the kit a minimum stock of basic units, without taps or bus bars, can replace any finished potentiometer of like design. Kit can be modified to meet production requirements. **Micro-Lectric Div., Micro Machine Works, Inc., 19 Debevoise Ave., Roosevelt, L. I., N. Y.**



High-torque actuator motor . . . starts or stops within 10 millisec at 60 cps and 5 millisec at 400 cps. Basically a lightweight, ac, rotary solenoid with a vibrating rate of 120 cps when operated on 60 cps ac. This vibratory motion is translated to rotary stepping motion through a fast-acting, one-way clutch. Adjustable for speed and torque. Can remain in a stalled condition without damage. Operates on 116 v, 60 cps, but can be supplied to operate at any voltage level for 60 cps and 400 cps ac. Will operate from pulsating dc. Models available deliver up to 10 in-lb at 15 rpm. **Viking Tool and Machine Corp., 20 Main St., Belleville 9, N. J.**

FOR OEM



Here are a few of the many items currently being manufactured by Beaird's Special Products Division for *original equipment manufacturers.*

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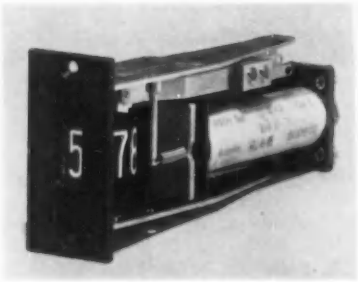


Versatile single decade counter . . .

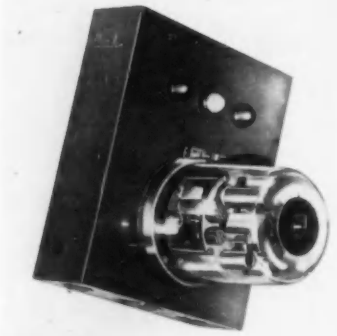
may be used for normal or backward counting at speeds to 25 impulses per sec, transmission of a remote numerical indication to a central location, and remote presetting for predetermining control. Counters have a single figure drum, measure $\frac{7}{8}$ x $1\frac{1}{4}$ x $4\frac{1}{8}$ in., and are for flush mounting. May be used independently as decades or combined as multi-digital counters. Indicated life is said to be over 50 million impulses. Watt consumption of a 10 impulses per sec, model, operating on 110 v dc, is 2.1 w. **Landis & Gyr, Inc., 45 W. 45th St., New York 36.**

Shear hub sprockets from stock . . .

are all-steel, with bronze-bushed sprocket and drill-rod shear pins in hardened bushings. Entire assembly is compact, with overhang held to minimum. Provides protection against overloads on any standard roller or conveyor chain drive. **Murray Equipment Co., Inc., 14011 Oakland Ave., Detroit 3.**

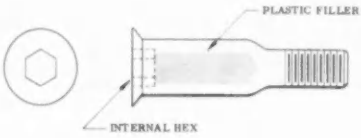
Camera for millimicrosecond photography . . .

uses an aperture 1.25 x 2 in., hermetically sealed shutter that can be synchronized to within 2 millimicrosec or less. Shutter mounts on a Crown Graphic '45. Connected by leads, it can be used at a location remote from the modulator unit. Electronic controls are contained in a 24 x 16 x 13 in.-high cabinet. Operates from 115 v ac. The camera can be triggered from a pulse as low as 50 v. Adjustable delay can be inserted between triggering pulse and shutter opening. Adaptable for use in photographing transient or impulsive phenomena, for instance, those that occur in shock tube studies, hyperballistic, aeroballistic and magneto-hydrodynamic studies, detonation and explosive phenomena, and electrical discharge processes. **Electro-Optical Instruments, Inc., P. O. Box 4234, Pasadena, Calif.**



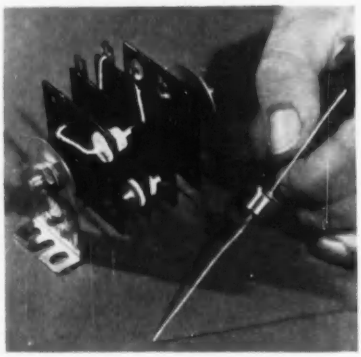
Electronic feed control . . .

maintains constant (within 5%) flow of solids or liquids into all kinds of motor-driven processing machines. **Load Star Corp., 1474 S. Vandeventer Ave., St. Louis 10.**



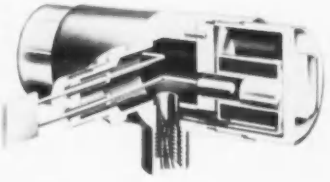
Lightweight alignment bolt . . .

re-aligns, through normal installation, any misalignment between wing-panel skins, access doors and structure, and heavy stainless steel honeycomb panels and primary structure. Manufactured in titanium, 431 stainless steel and other materials. A standard internal hex recess produces a large margin over maximum installation torques because the fasteners are designed for repeated installation and removal. Bolt is made by drilling a hole in shank, but not deep enough to reduce the section in the necked-down area. The hole, from the bottom of the hex down, is filled with nylon or thermosetting plastic, which also prevents trapping moisture. **Hi-Shear Rivet Tool Co., 2600 W. 247th St., Torrance, Calif.**



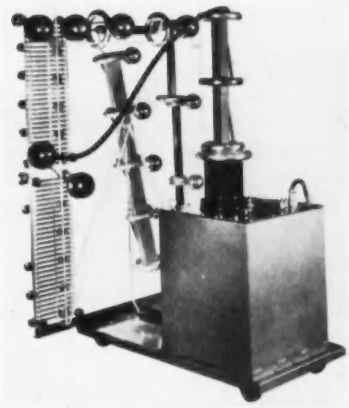
Silicon power rectifier . . .

provides dc forward currents to 1.6 amp, with a max peak inverse voltage to 800 v. Max forward voltage drop at 1 amp and 257 F case temperature is 1.3 v. Max operating frequency is 50 kc; operating junction temperature is 347 F. Rectifier case is the positive terminal. **Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30.**



Level control . . .

detects high or low points and provides proportional control within narrow ranges, of liquids, solids and slurries. It has a positive-acting, electrical output control signal that varies with the amount of immersion of the 120 cps vibrating paddle in the medium being detected. Output signal can be used to control the operation of electrical equipment. Design allows sensitive transmission of vibrational energy from the driver end to the sensing paddle and back to the output signal end through a linkage path welded to rigid metal pressure seals at the node points where zero vibration-amplitude occurs. Rated for 3000 psig. It is explosionproof on 115 v ac, corrosion-resistant and mounts in any position. $\frac{3}{4}$-in. NPT pipe opening is required. **Automation Products, Inc., 3030 Max Roy St., Houston 24.**



Air-insulated, power supply . . . is for high voltage and is selenium-rectified. It is a 250 kv, 2 ma unit. Supply has an input voltage of 105 to 125 v, 50 to 60 cps, single-phase input power of approximately 1 Kva, continuously variable output voltage, and manually reversible polarity. Ripple is approximately 2.5% at rated power output, internal impedance is 11 ohm. Has a 0-250 kv voltmeter and 0-5 microammeter with ± 3% full-scale accuracy. Protective features include provision for external safety interlock, zero start interlock, fixed overcurrent and overvoltage relays preset for 110% of rated output, short-circuit surge-current limiting resistor, gaseous discharge devices for protection of relays and meters, and spark gap to ground from meters and transformer primaries. This model is $5900. If not in stock, delivery is 90 to 120 days. Beta Electric Div., **Sorensen & Co., Inc., 333 E. 103rd St., New York 29.**

Adjustable torque handle . . . controls clamping pressure on jigs and fixtures, assemblies and machinery where ordinary torque thumb-screws would require machining to adapt to existing setups. End pressure is adjustable from 15 to 200 lb. Tapped hole is available in three sizes: $\frac{5}{16}$-18; $\frac{3}{8}$-16 and $\frac{1}{2}$-13. Aluminum handle is die-cast with a cast-in, hardened steel insert. **Vlier Engineering, Inc., 8900 Santa Monica Blvd., Los Angeles 46.**

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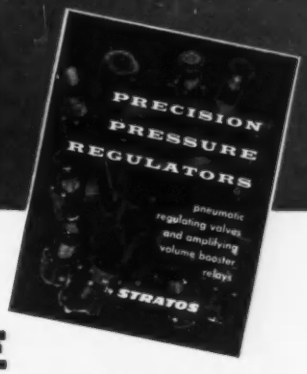

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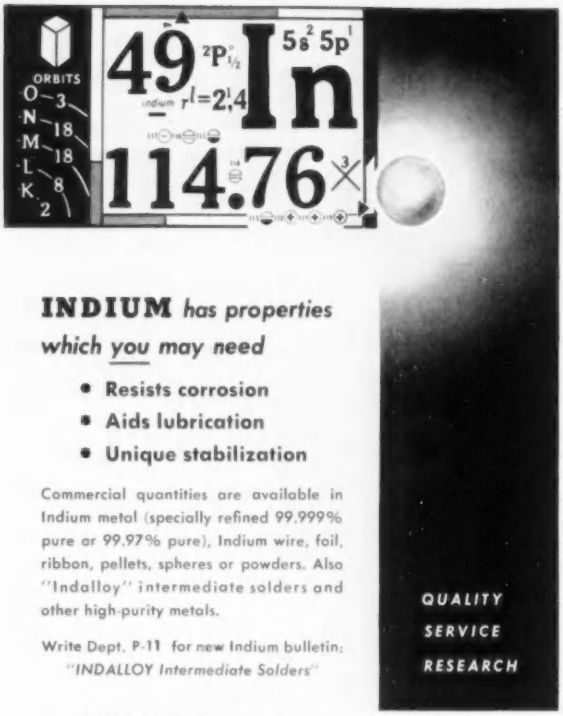

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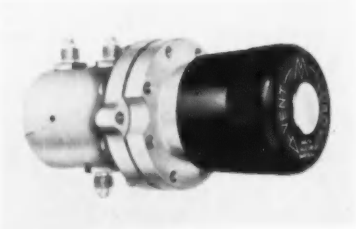
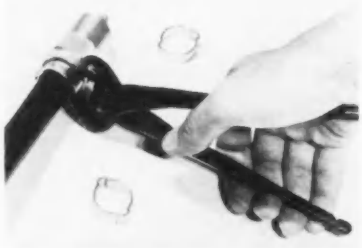
SIGNIFICANT PARTS MATERIALS EQUIPMENT . . .



Pneumatic regulator . . .

utilizes gas pressure for hand operation or three 18 to 30-v dc solenoids for remote-control operation, instead of spring mechanisms. Offers wider inlet and outlet pressure ranges and is versatile to the extent of permitting its integration into pneumatic systems requiring operation at predetermined pressure level sequence. Built-in relief valves act to compensate automatically for over-pressurization caused by human error or environmental conditions. Inlet-pressure range is from 500 to 4500 psig; outlet pressure ranges from 50 psig to 50 to 200 psig below inlet pressure. **Marotta Valve Corp., P. O. Box 330-40, Boonton, N. J.**



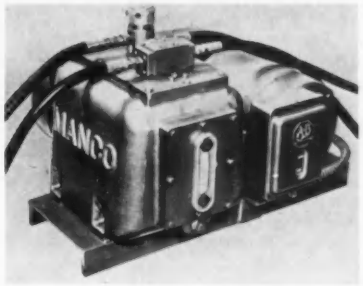
Hose clamp ferrule . . .

has several advantages over standard ferrules when used to attach solderless connectors to large-size coaxial cable. The one-piece, ring-like clamp with two U-shaped lugs is crimped tight by squeezing together the parallel sides of the lugs with a pincers. Only tool needed is an ordinary pincers. Clamp is 0.35 in. wide, with a wall thickness of 0.059 in. Available in 20 sizes from $\frac{1}{4}$ to $2\frac{5}{8}$ in. ID. **Circle Clamp Corp., 39 Broadway, New York City.**

Porous sponge Teflon . . .

in pore sizes from 5 to 50 microns and void contents of 5 to 55% for use in filtration, electronic and mechanical applications is now in production. Properties can be varied independently of one another. As a filter element, particles as small as 5 microns may be removed. It

has applications in extremely low-dielectric-loss components. Cost is based on pore size and void content. For example, with a pore of 18 microns, a range of from 12 to 24 microns and 55% voids, the Teflon would be priced at $12.25 per sq ft in sheets ¼ in. thick. **Liquid Nitrogen Processing Corp., 451 Booth St., Chester, Penna.**



Hydraulic power unit . . .
operates high-pressure hydraulic equipment. Adapts to varying requirements in the range 4.1 gpm at 5000 psi to 3 gpm at 8800 psi. An externally-located valve permits adjustment of pressure in the field. An internal safety relief valve is factory-set at 9000 psi for tool protection. A thermal overload protector is on the pump motor. The pump is powered by a 5-hp, 220/440-v, 60-cps motor operating at 1800 rpm. Available with gas-engine power. Basic unit is also offered with a selector valve that permits operation of two or more hydraulic units from the one power unit. **Manco Mfg. Co., Bradley, Ill.**

Percentage recycling timer . . .
in 12-time cycles from 15 sec to 24 hr, closes any electrical circuit for any desired part or percentage of a fixed time cycle. Dial is calibrated in terms of percent. On-time percentage of the cycle is adjustable from 3 to 97%. Continuous duty is obtained with 100% setting. Enclosed in dustproof metal cases that mounts through 3-in. hole. Driven by synchronous-motor; operates on 115 v ac, 60 cps. **Industrial Timer Corp., 1407 McCarter Highway, Newark 4, N. J.**

5-A-141

missile engineers

As space becomes the missile engineer's province the demand for highly competent talent is ever present. Each development uncovers other areas for advanced study.

Beneath the imposing skyline at Northrop, engineers in the new multi-million dollar Engineering and Science Center are tackling today the problems of tomorrow's flights into space.

Scientists and engineers at Northrop have many accomplishments to their credit, including the USAF-Northrop SM-62 Snark intercontinental guided missile, first such weapon system to become operational with the Strategic Air Command. Research continues on preliminary and advanced projects involving missile guidance and controls, propulsion, flight test engineering, and similar areas of prime importance.

Northrop's 18 years of experience in pilotless flight is seldom matched by other manufacturers in the aircraft or missile fields. This reputation is a principal reason why experienced engineers and scientists have joined the Northrop Engineering Division. As work progresses on the USAF Snark and other vital missile projects career opportunities become available for qualified missile engineers.

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NOV.

18-20 **National Industrial Conference Board,** management course on industrial utilization of radioisotopes at Westchester Country Club, Rye, N. Y. The course, moderated by representatives of the AEC and Battelle Memorial Institute, will cover industrial uses of radioisotopes in nontechnical terms. For information contact the NICB, 460 Park Ave., NYC.

18-20 **Air Conditioning and Refrigeration Exposition,** International Amphitheater, Chicago. Trade associations in the field will hold simultaneous conferences. For information contact Banner & Grief, 369 Lexington Ave., NYC.

19-21 **Investment Casting Institute,** annual fall meeting, Sheraton Hotel, Chicago. Technical sessions, Nov. 19, will compare induction and carbon arc techniques of melting high alloy steels. Sessions, Nov. 20, will cover business trends. For information contact the Institute, 27 E. Monroe St., Chicago.

DEC.

1-6 **ASME Annual Meeting,** Sheraton McAlpin and Statler Hotels, NYC. Schedules call for 12 to 15 simultaneous sessions to allow broad and specialized coverage of engineering developments. For information contact the Society, 29 W. 39th St., NYC.

2-6 **International Automation Exposition,** New York Trade Show Building. For information contact Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh, Penna.

9-13 **Joint Computer Conference,** sponsored by AIEE, IRE, and ACM, Shoreham and Sheraton Park Hotels, Washington, D. C. Agenda covers use of electronic "brains" for defense, industry, aircraft, earth satellites, automobile control, communications and business. For information contact the AIEE, 29 W. 39th St., NYC.

10-11 **Society of the Plastics Industry,** session of the Plastics Film, Sheeting, and Coated Fabrics Division, Hotel Commodore, NYC. Conference theme: Quality Vinyl Products in the Consumer Field. For information contact J. Roy Price, Bakelite Div., Union Carbide Corp., NYC.

18-19 **Maintainability of Electronic Equipment,** Conference of the Electronic Industries Association, Bovard Hall, University of California, Los Angeles. Sessions cover new concepts of maintainability problem, and design of equipment for easy maintanence. For information contact the EIA, 11 W. 42nd St., NYC.

JAN.

6-8 **Reliability and Quality Control Symposium,** sponsored jointly by the AIEE, RETMA, IRE and American Society for Quality Control at Hotel Statler, Washington, D. C. Includes 40 papers by industrial, government and military authors. For information contact AIEE, 29 W. 39th St., NYC.

FEB.

4-6 **Society of the Plastics Industry,** Reinforced Plastics Division, technical and management conference, Edgewater Beach Hotel, Chicago. For information contact the Society 67 W. 44th St., NYC.

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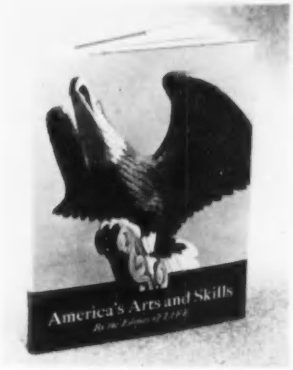

NEW LITERATURE

America's Arts and Skills

By the editors of Life Magazine. Published by E. P. Dutton & Co., Inc., 300 Fourth Ave., New York 10. 10½x14 in. 172 pp, $13.95.

More than just a collection of pictures to delight the antiquarian, this book is a background source of the best type for those who develop the products that Americans use and enjoy. Shown are both kitchen and production tools devised by our ancestors; timepieces that measured, and weapons that ended, the lives of Americans; the anatomy of traditional American housing and furniture—and the fire-fighting equipment that protected it. Ingenious mechanisms that built much of this country are included, together with examples of the machinery that first tilled the plains and puffed along the earliest iron rails.

This material originally appeared as separate articles in *Life*, between April 1955 and May 1956. Accompanying the more than 250 color pictures is 30,000-word text by Roger Butterfield, author of *The American Past*. J.K.

Long Shot: Competitive Electricity from Sunshine

Ample sun energy falls on the roof of the average house to meet its electrical needs. Based on measurements of average incident sunlight in the temperate zone, about 50-kw-hr of heat energy falls daily on an average roof. Assuming 5% conversion efficiency, roof collectors would generate 2½ times the power consumption of the average American home. However, a dollar barrier blocks growth of solar-power generation. Solar power today would cost about 54¢ per kw-hr, some 14 times the present price. But heat reaching earth's surface every four days equals that in our entire reserve of fossil fuels.

Distribution hikes cost of electricity at the home to as much as six times central-station cost. The difference may be exploited in a higher allowable capital cost for the installation.

A system of mirrors, photovoltaic cells and batteries would be used to convert solar energy to useful electricity, storing some for use when the sun is not shining.

Sufficient sun energy falls on most of the US to make photovoltaic plants possible. To give adequate power in winter, a reasonable design might assume an average power flux of 0.3 kw-hr per sq ft per day.

Yield of electricity depends on conversion efficiency of the photovoltaic cell. For silicon the limit is about 20% at room temperature, with 10 to 11% presently achieved. At 5% conversion efficiency this yield of electricity would be 0.015 kw-hr per sq ft per day. At 4¢ per kw-hr, this would be 0.06¢ sq ft day.

Applying the usual capital charge for utility plants, the plant supplying this power must not exceed $1.81 per sq ft. If mirrors concentrate the sunlight twenty-fold, permissible investment would be $36.20 for a 20-sq ft system. The mirror might cost $8, leaving $28.20 to be apportioned between cell and battery.

At present prices a battery for this system would cost about $120—exceeding the allowable $28.20. With six-fold reduction in battery cost, the 20-sq ft system would total: mirror $8, battery $20, and photovoltaic cell $8.20.

How realistic is a six-fold reduction in battery cost? Electrode materials comprise only about 1/30th total direct cost of storage. The inactive materials that account for the remainder become a target for cost reduction. Little hope exists for reducing costs still more by finding a cheaper electrochemical system. Lower battery costs must come from improved design and manufacturing.

Present cost of photovoltaic cells also exceeds allowable cost for the proposed system. Simplified manufacturing techniques are urgently needed because 90% of the cost currently lies in processing. *Abstracted from General Electric Review, Sept. 1957.*

Dimensions of the Human Figure

LLOYD W. SAHLEY, *President, Cleveland Designs and Consultants, Inc. (publisher), P. O. Box 3989, Shaker Sq. Station, Cleveland 20. 34 pp, 8½ in., $1.*

These dimensions are based on measurement of 6283 persons selected at random in and around Cleveland. Wide selection of nationalities and regional backgrounds are represented; all age groups and walks of life are said to have been covered.

This material was originally prepared for author's industrial design organization. It is intended for anyone designing or developing articles for use by humans. Dimension ranges are given in almost all cases.

ELECTRONIC DEVELOPMENT SERVICES–Brochure, 34 pp, describes organization specializing in electronic-system development and production. Gives history, facilities, personnel, and examples of work. Cubic Corp. 5575 Kearny Villa Road, San Diego 11, Calif.

MACHINERY DESIGN AND MANUFACTURE – Bulletin 157, 16 pp, describes facilities for engineering and production of special industrial machinery. Lake Erie Machinery Corp., 1001 Woodward Ave., Buffalo 17, N. Y.

EDUCATION AND USE OF TECHNICAL MANPOWER – Pamphlet, 25 pp, by the Council for Technological Advancement points out that to alleviate the engineer shortage the need is not so much for new approaches as for wide application of proved principles. Specifically: more science and engineering courses in high school, better vocational guidance to assure recruitment of gifted students, more financial aid to gifted students, higher salaries for teachers, more efficient use of teachers, more efficient use of engineers in industry by relieving them of work that may be performed by technicians, better incentives (both monetary and nonmonetary) to persuade technical men to remain in technical fields, better industry-education cooperation. Council for Technological Advancement, 1200-18 St., NW. Washington 6, D. C.

PRECISION COLOR–Bulletin FS-246, 8 pp. Describes a new instrument for color analysts that establishes permanent, reproductible color standards, matches difficult colors, and measures slight color changes. Unit converts color seen into a permanent numerical formula, and back into original color when desired. With graphs, photos and diagrams. Fisher Scientific, 717 Forbes, Pittsburgh 19.

ENGINEERING SERVICES–Brochure, 6 pp. Describes engineering and design facilities available to engineering and design executives to who wish to ease peak loads in their departments. Services include electronic digital computers to speed completion of projects and optimize designs, when needed. Allstates Design & Development Co., Inc., 25-27 N. Warren St., Trenton, N. J.

Onan
ELECTRIC PLANTS
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NEWS

New hydraulic unit pushes pipe with bulls-eye accuracy

On this job, electrical conduit is being pushed under an arterial highway, avoiding expensive trenching. The hydraulic unit, built by Mercury Hydraulics of Denver, can push pipe with amazing accuracy. On a difficult job, this unit pushed 2-inch conduit 186 feet with less than 8 inches deviation from the sighted line!

The hydraulic unit is driven by an Onan 5.5 H.P. "AJ" engine. This Onan model was selected because of its smoother running and many long wearing features such as extra-large bearing surfaces.

Onan engines deliver more horsepower hours per dollar, *step-up performance of power equipment*. **Gasoline models: 1-cyl. 5.5 H.P., 2-cyl. 12.9 H.P., 2-cyl. Diesel, 15 H.P.**

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Publisher's Postscript...

An Unexpected Spark

Talking the other day with the president of a large electrical equipment company, he said, "In my opinion the group of engineers for whom you publish your magazine has done more for this country than all the politicians, lawyers, bankers or business executives put together. Their designs, expressed in new or improved products, have raised our standard of living —their ideas, interpreted in products, have put us ahead of all the rest of the world.

"I remember our shop in the early thirties. It was a forest of belts from the ceiling to the driven machines. Then along came the National Recovery Administration with a new pricing schedule for electrical equipment making it possible for the machinery manufacturer to build motors and controls *into* the machines he was making. Industrials no longer had to buy their electrical equipment direct from the electrical manufacturer and install it on the machine or in the plant. The machinery builder suddenly was able to buy more advantageously than the industrial user. Soon the builder was able to eliminate the motor base plate, eliminate the ceiling belt drive, and offer his customer an integrated power-driven machine.

"The new price structure for electrical equipment that went into effect at NRA time was really the green light for the complete redesign of production machinery. The machine builder could buy motors and controls at a better discount than the industrial buyer of his machines. He could afford to build in the electrical equipment and sell the finished product at a profit.

"That's less than 25 years ago, and look at the progress we've made. From a corner in the engineering department, the product design function has blossomed out to become one of the most important divisions of our industrial enterprises."

We didn't think much of the NRA—but as we look back, the depression-stimulated operation, which neither labor nor management liked, did leave its imprint on the field of product design, and opened the door to the tremendous development we have seen the last 20 years.

A lot of water has run over the dam since those days. Product design engineering has grown from a relatively small group of misunderstood and underpaid engineers to a body many hundred thousand strong, now including the key men in industry who are planning America's future. Right now the investment in product research and development is a *multibillion* dollar operation growing and expanding at the rate of 15 to 20% a year.

We have progressed farther in product design and development since the NRA than we did in the century preceding it and, without question, the coming ten years' accomplishments will dwarf the great developments we have seen so far.

No businessman who had to operate under the NRA remembers it with affection. It was a sort of commercial strait jacket. But looking back, we have to give it credit for supplying the spark that gave machine redesign and product improvement its first really big lift. —A.H.

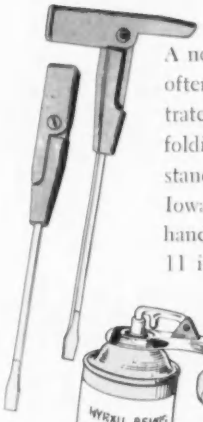
F.Y.I. (personal)

Automatic pipe-down

Ever try a phone conversation while the radio was blaring? Can't be done, of course. But scrambling for the radio (or TV) tone-down knob may be a bother too. Now, Tennessee Valley Development, Inc., PO Box 17, Oak Ridge, Tenn., has the solution: Sound Husher (Price: $2.25, postpaid). It inserts a resistor in series with the speaker to cut down the sound volume.

Sound Husher is simple: a clip with a built-in resistor and two contact wires, plus 30 ft of two-conductor wire for connecting it to the speaker. The clip attaches to the back of the telephone and extends forward under the handset. When the telephone is not in use, pressure of the handset closes the contact circuit built into the clip, and the resistor shorts out; but when the handset is lifted, the resistor steals current from the speaker, the noise level goes down, and you can hear yourself talk.

The better grip



A new handle can do wonders for an old product—and often create a brand new one. The screwdriver illustrated here is a good example. Its T-shaped handle, folding neatly down for storage (when not used as a standard grip) gives Kitchen-Quip, Inc., Waterlook, Iowa, a brand-new product. Cast aluminum in the handle holds the weight to 10 oz though the tool is 11 in. long, has a ⅛-in. bit. Price is $1.49.

Another example of a handle that makes a new product is the trigger-operated device (left). It fits over an aerosol spray can and holds down the spray button when the trigger is pulled. This would seem like painting the lily. Big advantage of aerosol sprays is supposed to be their convenience. But, says Sheffield Bronze Paint Corp., 17814 Waterloo Road, Cleveland 19, distributor of this device, it's difficult to exert steady, continuous pressure on the button. Price, $1.98.

Raising your boy to be an engineer?

Does Junior want to follow in father's footsteps? Give him a drafting kit for Christmas—and get a lift yourself from the fact that there are now at least two on the market, proof positive of the increasing importance of engineers. Kits like these used to be available only for budding doctors and chemists. T-square, protractor, compass, French curve, lettering guide are standard equipment.

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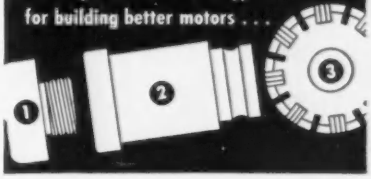
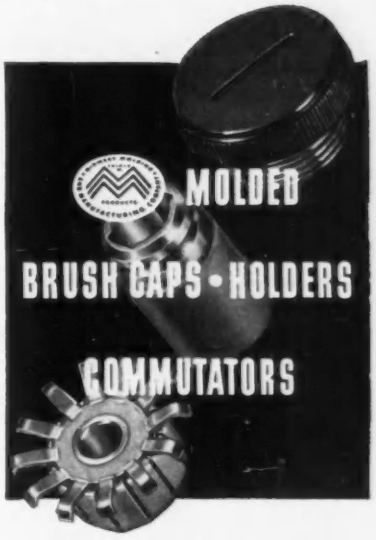


Design engineers and production planners use MMM as a dependable source for all 3 motor parts; available stock dies permit some variations in finish and materials.



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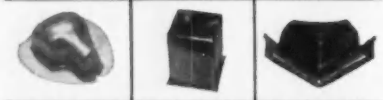

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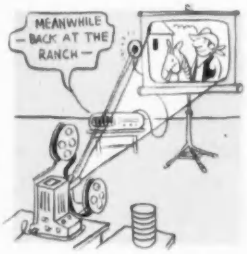
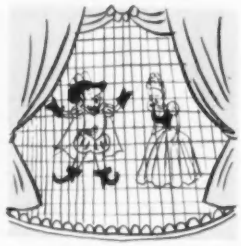


. . . a motion picture projector in which photoelectric pickup and associated sound equipment are located at the screen rather than at the projector. Normally an auxiliary lamp sends a light beam through the sound track. The modulated beam then strikes a photoelectric cell and the resultant electrical signal is amplified and sent to speakers near the screen. Radios and TV sets have the necessary amplification circuits and speakers, and a photoelectric cell could be mounted near the screen. The light beam would come from the projector lamp, be reflected or piped by light-conducting plastic through the sound gate and then to the cell. Cell output would go to radio, TV or hi fi input jack to reduce bulk, weight and cost of projector. Further, the speaker cable would be eliminated (a notorious source of trouble) as would the disturbing noises caused by sparking brushes and governors. —S. Hamilton, *Winnipeg, Man.*

. . . some practical home applications of Teflon's excellent frictional characteristics and its indifference to corrosive materials. How about a breadboard and rolling pin coated or impregnated with Teflon? It might also be used instead of the customary marble slab and as mixer paddles and spoons for sticky substances like candy and frosting.—Kenneth Kahn, *Yuma, Ariz.*



. . . a truly three-dimensional movie or TV screen? The volume of the "stage" would be a pattern of microscopically thin wires crisscrossing to give a 3-D network. Each junction could be triggered electrically by signaling the appropriate three coordinate wires, and would turn luminescent—giving a spot of light (and color). Groups of such lights could shape themselves into people, furniture, or any three-dimensional object: without limitations of scale, and viewable from any angle. Two major design problems: a junction to give off light when receiving three voltages and to change color in response to proportions of voltage; a recording and storage method for some 1200 channels (assuming an array of 400 x 400 x 400 wires).

Have you a pet project but neither the time nor inclination to do the necessary R & D? Product Engineering will welcome (and pay $10 each for) similar ideas based on known scientific principles but lacking an inspired manufacturer

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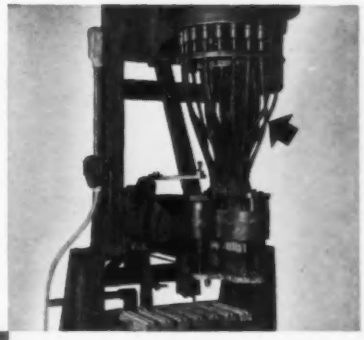

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